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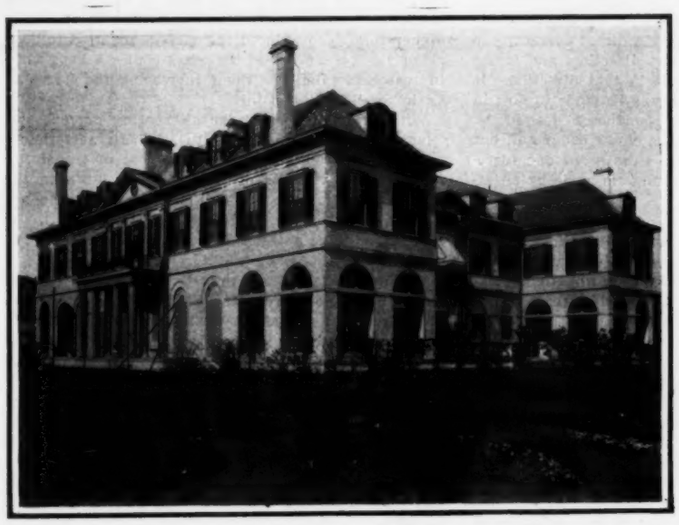

FIG. 1.—THE CONCRETE RESIDENCE OF MR. OLIVER AMES.

FIG. 2.—A GOOD EXAMPLE OF THE POSSIBILITIES OF CONCRETE.

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THE USES OF CONCRETE ON A COUNTRY ESTATE.—[SEE PAGE 408.]

DIRECT AND ALTERNATING CURRENT.

THE DIFFERENCE BETWEEN THE TWO SIMPLY EXPLAINED.

BY S. A. FLETCHER.

TO MANY a man who has had to do with electric current in some form or other the questions have arisen, either in his own mind while at work or in some discussion with a friend, What does direct current mean, and what is the difference between direct and alternating current? What is the need of having both? Would not one be sufficient?

Such questions are perfectly legitimate in every way, and an intelligent understanding of the answers to them may be of assistance to those who are trying to learn more about that mysterious power which is playing an ever-increasing important part in the industrial world.

In the first step to be taken in answering these questions, the nature of an electric current must be borne in mind. No man really knows exactly what an electric current is, but nevertheless a great deal is known about how currents act and what they will do under given conditions. It is this fact which really makes electric power so useful; it always does the same thing under the same set of conditions. It is dependable and is not freakish. Lightning is often said to be the same as the electric currents which are used to light our houses and drive our machinery, but it is not so, especially in this characteristic; lightning is most decidedly freakish, and you can never tell what it is going to do, largely, perhaps, because it is very difficult, if not impossible, to know what the conditions are which influence it.

An electric current is said to flow in a wire or other conductor (metals are in general the conductors) when it forms part of a circuit in which some source of electric pressure or voltage is present, without an equal opposing source of voltage. There could be a complete circuit with two equal and opposing electric pressures and no current would flow. It is to be noted that there must be a complete circuit without an opening, otherwise the current cannot flow. As the wire will not have any different appearance, whether carrying current or not, it is necessary to study the situation by means of instruments constructed to detect or measure electric currents.

This matter of being compelled to study a thing by its actions without knowing much about its nature is not limited to electric currents. It is well known what light does and its effects on various things, but no one knows exactly what light is. Nevertheless, the farmer makes use of the light and the heat from the sun when he plants his seeds. Just why the light calls forth the shoots from the seeds he does not know, nor does he need to know. So it is with electric currents. It is known how they act, and it is possible to make use of them, even though no one state their exact nature.

While a current is said to flow in the wire, it must not be thought there is any material substance passing along or inside the wire. It is true that the flow of electric current in wires has been compared to the flow of water in pipes, and for some purposes the comparison may be valuable, but it must not be forgotten that electricity itself does not resemble water, as electricity is not a material substance and has no weight; hence, no body, either liquid or solid, actually travels along the wire when an electric current passes.

Possibly a statement of the speed with which an electric current passes through a circuit, such as an ordinary lighting system, may help to emphasize the fact that electricity cannot be a material substance. It is a fact that current travels at the rate of 190,000 miles in one second. That is, it travels fast enough to pass seven times around the earth in one single second. As a matter of fact, if a line of cable were actually stretched around the earth it would take more than one second for the current to flow once around. But that is due in part to the fact that the cable must be laid in water for long distances, and when the current passes through these portions of the circuit it travels more slowly.

But even the actual speed attained in these cables is enormously high; so high that it is easy to see that no substance could be guided along or in the small wires used for electric current without flying off at corners or tearing the wire to pieces.

By speaking of the speed of the current as being of such a value, reference is made to the length of time that elapses after an electric current is closed, which gives the current a chance to start, before the current has traveled the entire circuit and returned to the starting point. After a current has once begun to flow in a circuit it continues to do so until an opening is made in the circuit, or the voltage causing the current to flow is removed. This time which it takes for the current to become established in the circuit is in all ordinary commercial lighting circuits not measurable, as it is so small a fraction of a second.

The direct current may now be explained to advantage. Direct current flows steadily in one direction through the circuit, just as the water in a city water system flows regularly in one direction, and does not flow backward or reverse in the pipes. This is due to the pressure caused by pumps or by the reservoir situated on the hill. Just so with direct current; the pressure is steadily in the same direction, and forces the current through the circuit in that direction. It is true that the direct current may be made to flow in either direction through any conductor desired by merely reversing the connections of the conductor, but nevertheless the current flows steadily in one direction or the other until some change is made by an attendant.

But alternating current is very different from this, and does not flow steadily in one direction, but is actually flowing first in one direction through the entire circuit and then in the opposite direction. That is, the current flows through the whole circuit in one direction, then its value decreases until the current becomes zero, when it instantly begins to flow in the opposite direction, increasing in strength until some definite highest value is reached (the amount depending upon the circuit and the voltage), and then falling to zero only to begin flowing again in the original direction. It continues to go through these changes or reverses with great regularity, varying ordinarily in a fairly smooth curve and not by jumps.

These changes take place very rapidly; in fact, the current in an ordinary lighting circuit actually reverses its direction 120 times a second. It is possible for the current to go through these rapid changes only because of the high speed at which it travels. If the speed were low—that is, comparable with the speed with which water travels through pipes—it would be absolutely impossible for the current to establish its flow in the entire circuit before it would have to begin flowing in the opposite direction. This would mean that parts of the circuit would receive no current at all. Such is not the case, as the current is actually at the same value throughout the entire circuit at the same instant.

In order to detect these reversals it is necessary to employ a special electrical instrument, such as a galvanometer. It has been possible by such a device with special arrangements of mirrors, lights, etc., to throw on a screen a representation of the actual varieties in the current exactly as they take place. It is also possible to photograph these curves by having the light fall on a photographic plate instead of a screen. Such an arrangement of instruments is of course expensive, and the outfit is of course very delicate.

Ordinarily, it is desired to know, not these rapid variations in the current, but the effective value, or the value that the current would have if it did not vary, and yet accomplish the same work. This value is shown by an ammeter connected in the circuit. The needle or pointer of the instrument does not vibrate in response to these rapid reversals of the current, but remains steady at the effective value of the current. This value shown by the ammeter is always known as the current in the circuit.

Most direct current ammeters, if connected in an alternating current circuit, would show a very rapid vibration of the pointer and would not indicate any correct value. Most alternating current meters will indicate correctly on a direct current circuit.

It must be understood that the difference between direct and alternating current depends upon the machine in which it is generated at the power house. Direct-current generators in general have a commutator as a prominent part, and in general alternating current generators have no commutator. There are exceptions to this rule, but the direct-current generators which have been built without commutators can almost, if not quite, be counted on the fingers of one hand, while the alternating current generators using commutators are special machines, with the commutators as a sort of side issue.

In answer to the question why it is necessary to have these two different sorts of current and which is the better, it may be stated that direct current was studied and developed some years before alternating current was understood. All the early generators were for direct current, largely because arc lamps were the main use for current, and direct current was all that could be used on the early lamps. Later the motors were developed for direct current and gave satisfaction.

When the incandescent lamps became more extensively used it was soon found that direct current could not be transmitted very far without very large wires or a large proportion of wasted power. It was found by study and then by experiment that alternating current could be generated and used at higher voltages than was possible with direct current, and that this higher voltage so reduced the current required to do a given piece of work that the wires could be kept within reasonable limits without increasing the losses to an impossibly high point.

With these higher voltage alternating current systems, special pieces of apparatus, called transformers, are required. These serve the purpose of transforming the high voltages of the generator down to the proper value for the lamps. These transformers are located close to the points where lamps are to be lighted, and do not produce any material waste of current.

Without these transformers the alternating current would be of no more value than the direct current. It is because a transformer will not operate on a direct current circuit that alternating current is used at all. In order that a transformer may lower the voltage as it does from one value to another without material waste, rapid fluctuations in the current must occur, just such as exist in alternating current circuits as the alternating current goes through its rapid changes. If a transformer were connected to a direct current circuit, no effect whatever would be obtained from the low voltage side; it absolutely refuses to work.

It is impossible to state in general that direct or alternating current is better, because for some purposes direct current is preferable and for others alternating current. In some cases there is little choice between the two, but in most cases there is a decided preference in favor of one or the other.

Direct current in general is used where the power is to be applied near the point where it is generated, as in small factories, office buildings, hotels, etc. In a machine shop direct current is ordinarily preferred, because it permits the use of adjustable speed motors, where the motor speed may be varied over a wide range, such as from 400 to 1,600 revolutions per minute. This allows direct connection of the motor to the machine tool.

Alternating current is used for distributing power over a scattered town or city or for use in a large factory. For transmission of power over long distances, as from Niagara to Rochester, alternating current is the only thing possible.

For street car work direct current has for many years been the only thing possible, because direct current motors were the only ones which had the proper characteristics. But within a few years motors have been developed which operate on alternating current with practically the same characteristics as direct-current motors. A number of alternating-current railways have been built especially for interurban work.

In general it may then be stated that both alternating and direct currents are used because each can be used in some places, where the other cannot. Neither can displace the other, as each is limited. A statement as to the relative importance of the two would be hard to make, either in terms of money invested or in terms of manufactured output per year.—American Journal of Steam and Electrical Engineering.

The microscopic examination of wood after it breaks in a testing apparatus has just been started by the Office of Wood Utilization in the Forest Service of the United States. Every species of wood has several different kinds of cells, each of which has its own size and form. There is also a wide variation in the number and arrangement of the cells in different species. These differences in structure have their bearing on the strength of the wood. For some time past the Forest Service has been carrying on a large number of tests on many kinds of wood in order to determine their strength, stiffness, elasticity, and other physical properties, so that they may be used to the best possible advantage in construction. The application of microscopic work to such tests is expected to give a better knowledge of the conditions on which the strength of wood depends. Other problems connected with the structure of wood, such as the preparation of wood pulp and the treatment of wood with preservatives, will probably be aided by this new study.

STEAM ENGINES VERSUS GAS ENGINES.

A COMPARISON IN ECONOMY.

ONE of the features of the Dayton meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was a discussion of the relative merits of the steam and gas engine. The statement of the question included and put especial stress upon the use of the exhaust for heating, and the papers dealt with that phase of the subject, but the discussion ran more to the dependability and mechanical fitness of the newer type of motor for exacting service.

F. W. Ballard, secretary of the society, presented an academic consideration of the subject, showing that, although the gas engine was the more efficient heat motor, the steam engine had the advantage when the exhaust steam could be utilized for heating. The possibility of a similar use of the exhaust from the gas engine is limited, because of the low fuel consumption and the large proportion of the heat in the fuel which is converted into work. In the exhaust of a simple, non-condensing steam engine there are discharged per hour about 30,000 heat units for each horse-power, and this would supply about 90 square feet of radiation; the exhaust of a gas engine containing only about 6,000 heat units per hour per horse-power would supply only about 20 square feet of radiation.

D. L. Fagnan told of a plant containing two gas engines, one of 9 and one of 30 horse-power, running 24 hours a day four months in the year and 12 hours a day the rest of the time; in this plant the average cost for the whole year was $200 per month. The fuel was illuminating gas at $1 per thousand cubic feet. With electric motors at about two cents per kilowatt-hour the cost got up to $350 a month, but with a greater load, and running 24 hours a day all the year around. Changing back to gas engines running on natural gas at 30 cents per thousand the bills dropped to $73.10 for the period between September 13 and October 27; the November bill was $29.72, December $57.60, January $39.12, February $40.84, and March $58, an average of $45 per month.

L. G. Findlay, of the De la Vergne Machine Company, presented the comparison between steam and gas engines of 1,000 and 200 horse-power, as shown in the table. Lines 36, 37, 38 and 39 of the table are computed on the basis of 80 per cent of the value of the steam consumed by the engine being available for heating, but no standing charges are made against the heating plant. Concerning the possibility of heating with gas-engine exhaust, Mr. Findlay said: "If we heat the jacket discharge water with exhaust gases to about 180 degrees Fahrenheit, making a hot-water system, we can heat about 3,000 cubic feet of space per brake horse-power up to 70 degrees. By rejecting the greater part of the jacket water and raising the rest to steam of, say, 5 pounds, we are able to make 2.48 pounds of steam per brake horse-power hour. Beyond this we cannot go except with an uneconomical engine."

The steam men objected to the comparison of steam and gas engines on the rated horse-power basis, because of the much greater overload capacity of the steam engine as compared with the gas engine. The subject will be continued at the Cleveland meeting in November.—Power.

COST OF 200 HORSE-POWER AND 1000 HORSE-POWER STEAM AND GAS PLANTS.

Assuming the 1000 horse-power engine is compound condensing and the 200 horse-power is a simple automatic cut-off engine; that the coal with steam plants and bituminous coal producer costs $2 per short ton, while anthracite is $4.50 per ton. Bituminous coal averaging 11,000 B.t.u. per pound and the anthracite 13,000 B.t.u., lower heat values.

	Load Factor.	Steam.				Producer Gas.							
						Bituminous.				Anthracite.			
		1000 H.P.		200 H.P.		1000 H.P.		200 H.P.		1000 H.P.		200 H.P.	
		Full.	50%	Full.	50%	Full.	50%	Full.	50%	Full.	50%	Full.	50%
1	Cost of engine per rated horse-power		18.00		14.00		40.00		44.00		40.00		44.00
2	Cost of piping per rated horse-power		6.00		5.00		3.50		3.00		3.50		3.00
3	Cost of condensers per rated horse-power		3.00		....		....		....		....		....
4	Cost of pumps, etc., per rated horse-power		0.50		....		....		....		....		....
5	Cost of air starting app. per rated horse-power		....		..		1.00		1.50		1.00		1.50
6	Total of engine plant		27.50		19.00		44.50		48.50		44.50		48.50
7	Depreciation, 4 per cent. on total		1.10		0.76		1.78		1.94		1.78		1.94
8	Repairs, 2 per cent. on total		0.55		0.38		0.89		0.97		0.89		0.97
9	Interest, 5 per cent. on total		1.37		0.95		2.22		2.42		2.22		2.42
10	Total of lines 7, 8, 9		3.02		2.09		4.89		5.33		4.89		5.33
11	Boilers per rated horse-power		10.00		12.00		....		....		....		....
12	Producers per rated horse-power		....		....		15.00		16.00		10.00		14.00
13	Chimneys and breeching per rated horse-power		7.00		3.50		....		....		....		....
14	Heaters, feed-pumps per rated horse-power		1.50		1.50		....		....		....		....
15	Auto. stokers or coal machinery per rated horse-power		5.00		....		2.00		....		2.00		....
16	Total of fuel plant		23.50		17.00		17.00		16.50		12.00		14.00
17	Depreciation, 8 per cent. on total cost		1.88		1.36		1.36		1.48		0.96		1.12
18	Repairs, 3 per cent. on total cost		0.70		0.51		0.51		0.55		0.36		0.42
19	Interest, 5 per cent. on total cost		1.17		0.85		0.85		0.92		0.60		0.70
20	Total of lines 17, 18, 19		3.75		2.72		2.72		2.95		1.92		2.24
21	Coal used in b.h.p.-hr. in lb.	2.00	2.20	4.75	6.30	1.10	1.80	1.10	1.80	0.90	1.40	0.90	1.40
22	Cost of coal per b.h.p. per day of 24 hr.	4.80	5.28	11.40	16.22	2.64	3.60	2.64	3.60	4.86	7.56	4.86	7.56
23	Attendance of engine b.h.p. per day of 24 hr.	1.20	2.40	3.00	6.00	1.05	2.10	....	....	1.05	2.10	....	....
24	Attendance of fuel plant per day of 24 hr.	0.65	1.30	1.75	3.50	0.75	1.50	3.75	7.50	0.70	1.40	3.75	7.50
25	Oil, waste and supplies	0.60	0.80	0.50	0.80	0.50	0.70	0.50	0.70	0.60	0.70	0.50	0.70
	Cents.												
26	Total daily expense per b.h.p. per 24-hr. day	7.15	9.78	16.65	25.52	4.94	7.90	6.80	11.80	7.11	11.76	9.11	15.76
27	Yearly oper. expenses 309 days per b.h.p., dollars	22.09	30.22	51.45	81.95	15.26	24.41	21.29	36.46	21.97	36.38	28.15	48.70
28	Cost of coal per b.h.p. per day of 10½ hr.	2.05	2.25	4.86	6.46	1.13	1.84	1.13	1.84	2.30	3.68	2.30	3.68
29	Attendance of engine b.h.p. per day of 10½ hr.	0.70	1.40	1.50	3.00	0 40	0.80	....	....	0.40	0.80	....	....
30	Attendance of fuel plant per day of 10½ hr.	0.38	0.56	0.88	1.75	0.45	0.90	2.00	4.00	0.45	0.90	2.00	4.00
31	Oil, waste and supplies per day of 10½ hr.	0.27	0.49	0.26	0.49	0.27	0.46	0.27	0.46	0.27	0.47	0.27	0.47
	Cents.												
32	Total daily expenses per day of 10½ hr.	3.30	4.70	7.50	11.70	2.25	3.70	3.40	6.00	3.42	5.75	4.57	8.05
33	Yearly oper. expenses 309 days per b.h.p., dollars	10.20	14.52	23.17	36.15	6.95	11.43	10.50	18.54	10.57	17.77	14.12	24.87
34	Yearly expenses lines 10, 20, 27 = 24-hr. day	28.86	43.76	56.26	93.57	22.87	39.63	$29.87	$53.02	28.78	49.93	39.72	63.84
35	Yearly expenses lines 10, 20, 33 = 10½-hr. day	16.97	28.06	27.98	45.77	14.56	26.56	$18.78	$35.10	17.38	31.39	21.79	40.01
36	Cost of power, all exhaust steam used for heating	24 -hr. day.		$37.61	$61.25								
37	Cost of power, same as line 36 but short run	10½-hr. day.		$19.07	$30.68								
38	Cost of power, 50 per cent. exhaust steam for heating	24 -hr. day.		42.41	69.56								
39	Cost of power, same as line 38 but short run	10½-hr. day.		21.11	34.90								
	Total cost, lines 6 + 16 for entire plant	$61,000.00		$7,200.00		$61,600.00		$13,400.00		$56,500.00		$12,800.00	
	Water evaporated per lb. coal, at 212°	10 00		8 00									

The novel process used in obtaining peat coal is based on an electrical treatment of the peat fibers, the time of drying of the worked peat substance being reduced from two to four months to a maximum of ten to fourteen days.

After a preliminary treatment in a mixing and crushing machine, the peat is fed by a screw conveyer to what is known as an electrical mouthpiece. This is the most important part of the outfit. It effects the electrical treatment of the peat fibers and consists of a tank 7 to 9 feet in length of a rectangular cross section 16 to 18 feet in clear width, the two broad sides of which form the electrodes.

During the passage of the peat through this tank, rotary or single-phase alternate currents are made to traverse the mass, thus uniformly electrolyzing the peat, without drying it appreciably. During this treatment, the peat fibers seem to give off any oil and resin they contain. While the chemical processes actually taking place in the electrical mouthpiece are by no means clearly understood, it may be safely stated that this is a most vital organ of the plant.

From the electrical mouthpiece, the peat masses are taken into a Dolberg peat machine, by which they are shaped into two endless strands of about 11 x 11 inches in cross section, which strands are, in turn, subdivided by a cutting machine into cubes of about 11 inches in length, width, and thickness.

The cubes are carried on planks, in batches of 28 each, into drying chambers containing 10 to 12 rows of superimposed shelves exposed to a forced draft, the air stream flowing between adjacent rows. Each drying chamber contains from 7,000 to 10,000 cubes, and according to the size of the blower producing the draft 20 to 30 chambers are combined to one system. A blower of about 15 horse-power is required for drying 32,000 cubes.

The cubes are kept in this drying chamber for 6 to 8 days according to the moisture of the air, becoming so hard that they no longer cohere. They are finally passed to the drying towers, which are pear-shaped recipients of 175 to 350 cubic feet capacity. The towers are provided each with a perforated bottom, through which the air passes to the interior. The exhaust steam from the driving engine is carried in three or four conduits through each tower recipient, and an exhauster located on the top discharges any air moistened by the contact with the imperfectly dried cubes. After 36 to 48 hours' operation, the tower (which like a blast furnace is kept constantly in action) is discharged from the bottom (most subject to the action of fresh air) in order to be refilled from the top with fresh peat cubes. The peat coal is then ready for delivery. The whole of the operation occupies only 10 to 12 days.

Peat coal thus made can be kept for weeks and months in the open air in any weather without undergoing any appreciable alteration. Although not brittle, it is of remarkable hardness. It can be cut with a knife into curling shavings and can be sawed and cleft with an ax without splintering. Hence no grit is produced.

While raw peat contains 80 to 90 per cent, and ordinary worked peat (obtained after three to four months' drying) 45 to 50 per cent of water, peat coal contains only 25 to 39 per cent. It is true that the drying process can even be carried farther. The manufacture of peat coal would then be less economical. The cost of the manufacture of peat coal is less than 5 marks ($1.25) per ton.

PEAT COAL.

By DR. ALFRED GRADENWITZ.

PEAT coal is a product obtained by Baron von Morsey-Picard and Baron von Verschuer by means of a special process without the application of any pressure or heat. Free from the most undesirable properties of peat (its high percentage of water, loose consistency, and low heating value), this substance much resembles ordinary lignite. While most attempts to reduce peat to briquettes by applying pressure and heat have proved unsuccessful in practice, peat coal has been obtained with good results on a large scale, an extensive experimental plant with an 80-horse-power portable engine installed near Lüneburg having been worked satisfactorily for a year.

A NEW LEATHER AUTOMOBILE TIRE GUARANTEED FOR 10,000 MILES.

TIRE trouble has from the first been the bugbear which has seemingly been inseparable from the lot of the automobile owner or user, and yet fully as much ingenuity has been expended upon the perfection of tires which should answer all conditions of extremely exacting service as upon the driving mechanism itself.

With the perfection of the new mineral tanning processes for the treatment of leather, an exceedingly tough, pliable, and serviceable material was developed, which was quickly levied upon for use in the composition of automobile tires. Some were made entirely of the new chrome leather or used in combination with rubber, canvas, and other materials which are ordinarily utilized in tire construction.

Of the several leather tires which have been offered to the motoring public as a charm against dreaded tire troubles, there is one type which so combines the use of leather, canvas, rubber, and steel in its construction, that the best possible service is obtained from each material. This tire, suggestively called the Ke-pa-go-in, is made by the Beebe-Elliott Company, of Racine, Wis.

There are a number of features about the tire, both in material and method of construction, which place it in a class by itself. Its makers are so well satisfied as to its remarkable service-giving qualities, that they are not content with the usual 2,000 to 4,000 miles service life of the ordinary rubber tire, but guarantee 10,000 miles service for their 3-inch and 3½-inch tires, 7,000 miles for the 4-inch, and 5,000 miles for the 5-inch tires, or agree to replace tires without question.

The result of the combination of materials used in the construction of these tires is a puncture-proof leather tread, rendered skid-proof by the use of cold-drawn steel rivets, and reinforced by canvas and rubber carcasses of the type ordinarily used in rubber-tire construction. The leather is thoroughly waterproofed in the tanning process. There are no glued lap joints of leather to open after a short time in service. The rivets are put in to stay, being driven through two thicknesses of leather and resting against a third. Rubber is used for its adhesive qualities, and not where its strength will be taxed beyond reasonable limits, as in the ordinary tire.

The lining next to the inner tube is of a soft, tight-fitting material, making a smooth, frictionless wall. The heat generated in the tire casing, caused by the compression of air in the inner tube, is radiated off through the steel rivets in the casing as they travel rapidly through the outer air or come in contact with the cooler pavement.

But the unique feature of this particular tire construction is found in the method used of building up the tread in such a manner that whole sections of it may be renewed at the factory, and new ones substituted. Most tires have to be discarded entirely when a

serious injury happens to one part, making the whole tire unrepairable. This feature of the tire in question gives it a possible lease of life equal to four ordinary tires, and limited only by the life of the inner fabrics. Compared with the average rubber tire, the Ke-pago-in excels in durability, because the leather from which it is made has several times the tensile strength of rubber. It is an undisputed fact that rubber tires deteriorate, whether in service or standing on the floor of the garage. Leather is easily protected from disintegration by an occasional dressing with a prepared oil.

CONCRETE ARMOR FOR WARSHIPS.

A SUBSTITUTE FOR STEEL.

AT the congress of Italian naval engineers which met at Genoa in January, Lorenzo d'Adda described his project of constructing armor plates of reinforced concrete. D'Adda's concrete is made of a specially-prepared cement mixed with hard stone and sand, but the exact composition and method of manufacture are kept secret. Its specific gravity is about 2.25 and its cost $10 or $12 per ton. The specific gravity of Krupp steel is 8.1. D'Adda asserts that five inches of his reinforced concrete will resist armor-piercing projectiles, and three inches will resist shells as well as one inch of Krupp steel. The interior of the concrete armor contains a network of stout iron bars as an additional reinforcement. The hardness of the concrete is graduated like that of Krupp steel armor, the outer layer being harder than the interior.

The idea of using concrete for armor was suggested to the inventor by the remarkable resistance opposed in the siege of Port Arthur to the Russian projectiles by the Japanese casemates, which were made of concrete, without any reinforcement, and by the results of experiment and practical experience in other countries, in regard to the effect of gun fire on concrete. A series of experiments will soon be made at the Italian naval station at Spezzia for the purpose of determining the effect of shots on D'Adda's "armored concrete" plates, which are covered with thin plates of steel.

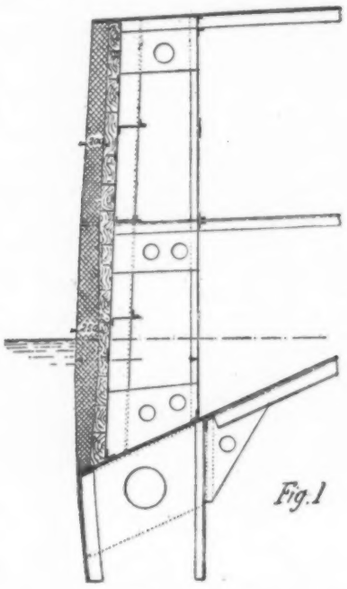


Fig. 1

STEEL ARMOR.

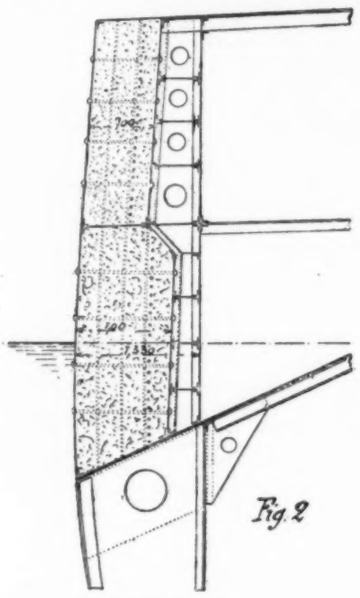


Fig. 2

CONCRETE ARMOR.

TRANSVERSE SECTION OF SIDE OF BATTLESHIP "REGINA ELENA."

As actually armored with steel and as it would appear with equivalent armor of reinforced concrete.

The inventor contends, very properly, that there is a great difference between the proving ground and the naval battle and that at the former the advantage is all in favor of the projectile. The actual conditions of war are so different that it is not fair to estimate the protection given to the ship by its armor by the results of tests made at the proving station. The penetrating power of projectiles is dependent upon various conditions which cannot be foreseen. If concrete affords sufficient protection to land fortifications, it ought to be equally effective when applied to a floating fortress. The great displacement of modern warships will permit the carrying of concrete armor of a thickness of 60 inches at the waterline and 40 inches above it. At the usual fighting distance 60 inches of reinforced concrete of the best construction cannot be pierced by a 12-inch armor-piercing projectile. The steel point of such a projectile would be softened, if not melted, by the heat of impact and friction before it had gone through 24 inches of hard concrete, and the remnant of its penetrating power would be destroyed by the chemical action of the ingredients of the concrete. On the other hand, explosive shells could not penetrate to any great depth but would burst and waste their force on the outer layers. D'Adda exhibited drawings showing the possible application of his concrete armor to the new battleship "Regina Elena," and stated that it would cost 7 million lire ($1,400,000) less than the steel armor actually used without increasing the weight of the vessel.

ATLANTIC STEAMING RECORDS—WHAT THEY COST.

BREAKING records in passages across the Atlantic is an expensive business. The cost of the voyage increases with every knot which is forced out of engines and machinery, and in the end nothing of great importance is gained. The North German Lloyd liner the "Kaiser Wilhelm II." has steamed from Sandy Hook to Plymouth in less than five days ten hours, taking the southern or longer course. The actual sea passage of the "Kaiser Wilhelm II." is considerably shorter than that of any of the other vessels engaged in the Transatlantic service except those of the Cunard Company. The "Lusitania" and "Mauretania," which, of course, are steamers of a much more powerful type, still retain the "blue ribbon of the Atlantic" for Great Britain. Only lately the "Lusitania" has completed the voyage from Queenstown to New York in 4 days 15 hours at an average speed of 25.23 knots, nearly four hours less than her own best previous time (4 days 18 hours 40 mins., in November, 1907). The "Mauretania" is almost as swift, with her "record" of 4 days 20 hours 15 mins., and an average speed of 24.8 in June last. A correspondent of the Times contrasts these remarkable speeds with the beginnings of the steamship service between the old world and the new. The "Royal William," the first steamer to cross the Atlantic, went from Pictou, N. S., to Gravesend in 1833 in 22 days. Five years later the Cork steamer "Sirius" accomplished the voyage to New York in 18 days, after burning everything on board that could feed the engines. The "Great Western," which had been built specially for the service, reached New York on the same day, having left Bristol three days after the "Sirius"—a passage of 14½ days. Two years later, the "Britannia," the first Cunarder, initiated the mail service between Liverpool and New York. The period between 1840 and 1860 was one of great activity in the development of the Atlantic traffic and in the improvement of the steamers engaged in it. It was not until 1862, however, that the passage was reduced to nine days by the "Scotia." Thirteen years later, in 1875 and 1876, the White Star liners "Germanic" and "Britannic," in competition with the Inman liner the "City of Berlin," steamed between New York and Queenstown in periods that varied from 7 days 16 hours to 7 days 13 hours. In the next few years the time was only very gradually reduced, but in 1882 the "Alaska" completed the same passage in 6 days 22 hours—a sufficiently striking performance at that time. Ten or twelve years later came the "Lucania" and "Campania," which gained for the Cunard Company the distinction of a five-and-a-half days' passage. It seemed impossible then to improve upon this feat, but already nearly another day has been saved, and the steamship companies apparently are not yet at the end of their resources.—The Steamship.

SEASONING AND TREATING TELEPHONE POLE CROSS-ARMS.

THERE are used every year in the United States about 14,000,000 cross-arms for telephone and telegraph poles. Of these, perhaps one-fourth are now treated with preservatives to increase their durability, and there are at least five plants, at New York city, Norfolk, Va., New Orleans and Slidell, La., and West Pascagoula, Miss., at which cross-arms are treated. Because of their small size as compared with the strength required and the weakening effect of the holes for insulator pins, and their constant exposure to all kinds of weather, cross-arms should receive a thorough treatment. A good treatment with creosote will at least treble their durability.

A large portion of the supply of cross-arms comes from the South; they are sawed from the loblolly or old field pine, of which there is a large quantity throughout this region. This tree grows rapidly, but contains much sapwood, which is difficult to season. It has been said that "loblolly pine sapwood will rot before it will season in the warm, damp climate of the South." While this is probably overdrawn, it is necessary so to pile the cross-arms that the air may circulate freely about them, and to protect them from rain and snow by a roof of loose boards. By laying twenty cross-arms in a tier, two cross-arms at each side and two in the middle set on edge, and allowing a small space between each of the others, which are laid flat, favorable conditions for seasoning are established and no rotting will occur.

Sapwood absorbs preservative so much more readily than heartwood that when both cross-arms in which sapwood abounds and those in which heartwood predominates are treated in the same run the former absorb an excessive amount before the latter have received what they require. This is not only a needless expense but a detriment, inasmuch as the excess of creosote in the sapwood later oozes out and drips on those who walk beneath. To solve this difficulty, the cross-arms should be sorted in three classes, as sapwood, intermediate, and heartwood, and treated in different runs.

Cross-arms are treated in large horizontal cylinders varying from 90 to 180 feet in length and from 6 to 7 feet in diameter. Into these the arms are run on skeleton trucks, and the doors are then bolted air-tight. Creosote is next run until the remaining space in the cylinder is filled. Pressure is sometimes then applied by pumps to force the preservative into the wood. In some instances before the preservative treatment the cross-arms are treated to a bath of living steam followed by the drawing of a vacuum, to remove moisture and secure rapid penetration of the wood by the preservative. It is the opinion of the Forest Service, however, that the bath in steam is not necessary or desirable if the arms are properly air seasoned. Other recommendations for seasoning and treating cross-arms, and a discussion of the methods now in use, are contained in Circular 151 of the Forest Service, which can be had upon application to The Forester at Washington.

The production of coal gas in the United States in 1907, as reported to the U. S. Geological Survey, was 58,096,478,402 cubic feet. Reports were received from 513 companies operating coal gas works and by-product coke works. The net product sold was 54,696,797,893 cubic feet, the remainder being lost through leakage, fire, etc. The average value was 66 cents per thousand cubic feet. These figures show, compared with those of 1905, an increase of 14,242,582,761 cubic feet in the quantity of gas sold and a decrease of 15.4 cents per thousand cubic feet in the price. Pennsylvania in 1907 superseded New York as the greatest producer and consumer of coal gas.

AERONAUTIC PRINCIPLES.

A SUMMARY OF FLYING MACHINE PROGRESS.

BY G. H. BRYAN.

A VERY interesting summary of progress in aviation up to the day of publication is afforded by M. Armengaud, junior's, book.* It is based on a lecture delivered on February 16 at the Conservatoire des Arts et Métiers, and it contains, in addition to an account of recent work, references to the early researches of Penaud, Marey, and others on flight of birds. A feature of special interest is the diagram showing the various systems of aeroplanes used by different experimenters. The illustration accompanying this article is based on the diagram in question, but we have omitted the purely gliding machines of Wright and Archdeacon, and have inserted the Farman "flying fish" type, as well as a figure of the mechanically-propelled Wright model based on the sketch in the SCIENTIFIC AMERICAN.

On looking at this table the average man whose education on current topics does not extend beyond the level of the newspaper will ask, "Which is the best flying machine?" As the interrogator usually is under the prevalent delusion that "a straightforward answer to a straightforward question" is all that is necessary to settle, once and for all, the most complex problem of science, and as he probably will forget all that has been told him when he reads about the next football match, the best way of satisfying him is to give a definite answer by choosing one at random from this diagram and saying it is the best. A general discussion of the different types of flying machine, including, not only aeroplanes, but orthopters and helicopters, is given by M. Armengaud, and this probably contains as much as could be embodied in a small handbook. But a complete examination of the conditions required to give the best results involves the discussion of at least two qualities, efficiency and stability, and while engineers have shown themselves fully competent to deal with the first of these qualities, a full discussion of the latter still involves the expenditure of a large number of brain-power hours of work at the hands of a really competent mathematician, and it will be one of the objects of this note to direct attention to some of the most important unanswered questions involved in the theory sketched out some years ago by the present writer, with the assistance of Mr. Williams.

Capt. Paul Renard's two papers on dirigibles† may at this stage be studied with advantage. The first paper is mainly theoretical, the second descriptive.

Taking the second part first, it contains an illustrated description of all the principal dirigibles that have been constructed, and of a number that have been projected. Capt. Renard expresses the opinion that France, which has produced a Montgolfier and a Col. Renard (whose early experiences with "La France" were greatly in advance of their times), is still to the forefront in aerial navigation by means of airships. He considers, further, that in spite of its interesting details of construction, the Zeppelin aerostat is not to be regarded as a model to be copied. These views we quote, without comment, on the authority of their exponent. The first or theoretical part contains a simple exposition of the elementary principles on which the success or failure of directed aerostats depends. In the first place, the relative velocity of propulsion (*vitesse propre*) must exceed the velocity of the wind if the aerostat is to be completely under control, otherwise the course will be confined within a limited angle. This fact every student of elementary mechanics ought to realize at a glance, but many who succeed in passing examinations fail to do so, and thus Capt. Renard's remarks are not so superfluous as they might seem to be to a person who really understood elementary mathematics. As the present writer pointed out, it is mainly the difference in speed between air currents and ocean currents which has rendered aerial navigation less successful hitherto than ocean navigation.‡

Capt. Renard discusses the questions of permanence of form and the relative advantages of large and small screws, and then proceeds to the question of stability. He distinguishes three different kinds of stability, namely, stability in altitude, stability of course, and longitudinal stability. According to the conditions assumed in text-books, when a balloon is in equilibrium at any altitude that equilibrium is stable, so that "instability in altitude" is not a mechanical effect, but consists in the effects of physical causes in disturbing the vertical equilibrium of a balloon; in a dirigible there are many easy methods of maintaining a constant altitude. Instability of course or instability in a horizontal plane occurs when an aerostat tends to turn about a vertical axis so as to set itself at right angles to the direction of motion, like the ellipsoids of our text-books in hydrodynamics. In longitudinal instability the aerostat tends to turn about a horizontal axis, pitching over forward or backward. Capt. Renard points out (and this is entirely in accordance with the present writer's investigations) that there is a certain limiting or *critical* velocity consistent with stability; in the case of the dirigible the critical velocity is a superior limit, which cannot be exceeded without the motion becoming unstable. He also clearly shows that this fact was known to Col. Renard in 1904, and further that the critical velocity in question in many types of machine, such as the "La France," "Lebaudy," and "Patrie," has fallen considerably below the maximum speed obtainable from suitable motors. For example, "In the 'Santos Dumont' the critical velocity is 8.50 meters (per second), and a 7-horse-power engine is sufficient to obtain it; if longitudinal stability were assured, the aerostat could be provided with a 22-horse-power engine and attain a speed of 12.10 meters. For 'Lebaudy' the critical velocity is 10.80 meters, requiring 41 horse-power. If this aerostat were stable it could carry a machine of 95 horse-power, which would give it a proper velocity of 14.20 meters."

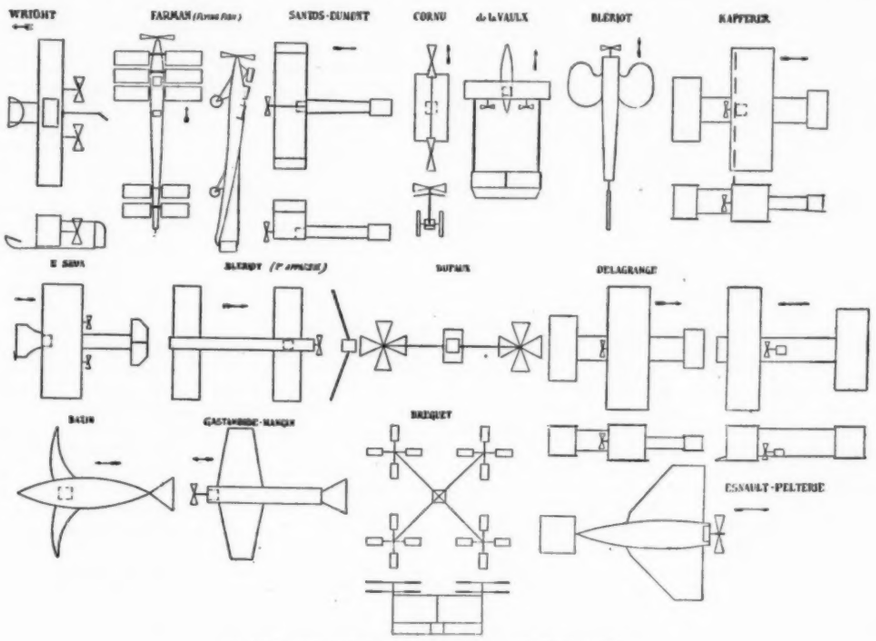
Yet we find another writer attempting to compare the stability of the "Patrie" and "Zeppelin" in a paper bristling with unnecessary mathematical formulæ, which do not even correctly represent the oscillations of the balloons about a statical state of equilibrium.* All the calculation really does is to treat the balloons as simple pendulums the points of support of which are at the centers of buoyancy, and the masses of which are concentrated in the cars. The use of the word "moment of inertia" tends to conceal the fact that the moment of inertia of the framework about its center of gravity is completely ignored.

Passing on to the equilibrium and stability of aeroplane systems, we find that not only is there a widespread neglect of even some of the most elementary mathematical principles underlying the subject, but the experimental evidence commonly accessible is insufficient to enable any very definite conclusions to be drawn as to the best form of a flying-machine or as to how far the types which have admittedly given successful results are capable of improvement. The lift and drift of aeroplanes have been carefully measured, and so far as the problem of flight depends on their numerical magnitudes, the theory of the aeroplane is summed up "in a nutshell" on pages 40 and 41 of M. Armengaud's paper.

In the construction of motors the main, if not the only, object to be aimed at is to make the weight as small as possible for a given horse-power, a problem with which engineers have shown themselves sufficiently competent to deal. The best system of aeroplanes from the point of view of general efficiency is that which requires the least horse-power to sustain a given total load in horizontal flight. The actual arrangement of the planes will not affect the efficiency except when one plane is placed in the wake of another. But in connection with equilibrium and stability the conditions are very complex, and a great deal of difficult mathematics is required.

Take the question of propellers. The present critic makes no claim to have examined the literature that has collected around this problem in connection with its more or less closely allied applications to naval architecture, but it is certain that what has been found out regarding the efficiency of a ship's screw should form a starting point for discussions relating to airship-propellers, account being taken of necessary modifications. Yet the most crude methods are forming the subject of published papers at the present time. C. M. Woodward's problems* would make suitable examples for a conventional text-book on "dogmatics" (as dynamics should be called) if their working were correct, but the expression for the rate of working in driving an airship through the air involves an error closely resembling that made when the oar is treated as a lever of the second class. The succeeding results regarding the horse-power applied to the screw would therefore be incorrect even if the fundamental assumptions were justified. W. B. Parsons† deals mainly with experiments, but it may be reasonably doubted whether he has really kept the *power* of his motor constant when the inclination of his blades has been varied. To do so the torque would have to be inversely proportional to the angular velocity. Neither the stated method of regulating the power nor the statement "The consequent variation in velocity is the expression of the air resistance for that inclination and velocity" (whatever this may mean) appears reconcilable with this assumption.

But to come to the important question of stability, of which longitudinal stability, being the most important, shall alone be considered here. A large proportion of the contributors to aeronautical journals have the vaguest possible ideas as to what stability means.



PLANS OF THE PRINCIPAL AEROPLANES.

From "Le Problème de l'Aviation," with slight modification.

* "Le Problème de l'Aviation, sa Solution par l'Aéroplane" (Paris: Ch. Delagrave). Price, 2.50 francs.

† "Les Aérostats dirigeables" (Revue Generale des Sciences, June 15 and 30, 1908).

‡ Cornhill Magazine, May, 1907.

* Capt. Guido Castagneris in the Aeronautical Journal for July, 1908.

* "Airship Propeller Problems," Trans. Acad. Sci., St. Louis, XXII., No. 1.

† Aeronautical Journal, April, 1908.

The successful flights of Farman, Delagrange, and Wright do not enable us to infer without further evidence that their machines are automatically stable. The analogous problem of the bicycle illustrates this fact. The lateral stability of the bicycle, like the longitudinal stability of the aerostat or aeroplane, depends, we believe, on the roots of a biquadratic equation, but in this case there appear to be two critical velocities, one an inferior and the other a superior limit to the speed. Of these the superior limit has been reached in bicycling in the wake of an express train. But bicycles are frequently ridden at speeds below the inferior limit, being kept upright by careful balancing involving no *conscious* effort on the part of the rider. It is highly probable that in many circumstances longitudinal instability may be equally well counteracted by the unconscious efforts of the aviator. Regarding the recent successes, evidence is far too conflicting to enable judgment to be passed in this review as to whether the machines were really stable, though there is equally no evidence to show that they were not.

Chanute long ago experimented on automatic stability, and stated that his gliding machines had special appliances for securing it.* It is scarcely possible that Chanute's methods have not been utilized by the Wrights. Yet according to the papers the French aviators, while expressing great admiration for the Wright performances, are of opinion that the successful balancing of the Wright machine is mainly a feat of skill on the part of the aviator, and that their object has been to construct machines with which anyone can fly. In support of this view we read that "neither M. Delagrange nor Mr. Farman had ever driven an aeroplane before the last eight months."† On the other hand, we were told more than a year ago that "Now M. Leon Delagrange, after making quite a number of short flights (the longest about 200 feet) with his motor flying machine, has found it advisable to go with M. Voisin, the cleverest of the French flying-machine pilots, to experiment with a gliding machine on the sand-hills near Le Touquet."‡

However probable it may be that a man-carrying machine is automatically stable, the performance of a successful directed flight can never definitely answer the question how far the success is due to automatic stability and how far to the skill of the operator. It may be that with a little experience something short of truly automatic stability is sufficient for all practical purposes; on the other hand, a great many writers who place their views before the public insist on automatic stability as a *sine quâ non*. The evidence derived from uncontrolled aerodromes such as those used by Langley enables the question of automatic stability to be tested much more definitely. The recent reprint of Langley's researches will always prove a valuable contribution to the literature of aviation.§ But in employing results of experiments with small models to draw conclusions about larger machines, everything depends on a correct appreciation of the theory of dimensions, and who is there that is sufficient of a mathematician that he can be absolutely trusted not to drop into one of the innumerable pitfalls that beset this elusive but valuable method of generalization?

Even to make a machine fly steadily in a horizontal line at all, three conditions are required. It is not sufficient that the drift should equal the thrust of the propeller (supposed horizontal), and that the lift should equal the weight. There is the third condition that the three forces, weight, propeller thrust, and resultant air resistance, must pass through one point, or an equivalent condition obtained by equating moments. If this condition is satisfied, but not otherwise, the machine is properly *balanced*, and may fly straight. But its flight is not necessarily *stable*, and it may upset at any moment. To find if it is longitudinally stable we must examine what happens if it deviates from its course and begins to pitch. To specify its motion at any instant in this case *three* variables are required, as every student of elementary mechanics ought to know. The resultant air resistance will also be altered, and to specify the new resultant three other variables will be required. The connection between these and the preceding three depends on the laws of aerial resistance. This connection is specified by certain "coefficients of stability," the values of which are necessarily based on experimental knowledge. On the assumption that if these are known, and the weight, position of the center of gravity and moment of inertia of the flying machine are known, the oscillations have been worked out and the condition of stability determined. This condition is conveniently expressible in terms of a critical velocity, it being necessary for stability that the velocity of a machine flying in a given manner should not be less than the corresponding critical velocity given by theory. In the case of a balloon we have learnt, on the other hand, that the velocity must not be greater than the critical velocity. The existence of a critical velocity was recently pointed out by Mr. Lanchester in a communication to the British Association, and it is to be hoped that his remarks will carry some weight with the pre-eminently unpractical "practical men" who abound everywhere.

When these results were obtained it still remained to reduce the problem of stability to the form of rules which were not beyond the ken of the ordinary working mechanic, and, further, to show how the necessary data could be obtained from experiments on models. Had the present writer been able to give his whole time to this work the problem of stability would have been thrashed out to the bitter end long ago. Looking at the matter perfectly impartially, and in view of many cases of a similar kind that may occur in almost any branch of science, the question may be asked whether it is desirable that the completion of such investigations should be delayed indefinitely because those who are prepared to undertake them are debarred by their professional duties from giving the necessary time? The cost of a mathematician's time in working out such a problem would probably not exceed the cost of building a single flying-machine, so that the existing method of trial and error is certainly not to be recommended on the ground of *cheapness*.

The critical velocity of a machine moving in air depends on the position of its center of gravity, the moment of inertia of the machine, the form, dimensions, and position of its supporting surfaces and tail, and the position of its propeller. In some cases stability may be increased by increasing the moment of inertia; in other cases it may be decreased. Our work tended to show that a machine might become unstable if the moment of inertia were *either* too large or too small, other things being kept constant. But when the mathematical theory has been worked out in every detail, the coefficients of stability for any given machine must necessarily depend on experimental data. Now the average mechanic understands the importance of finding the resultant thrust on an aeroplane, but he does not realize the necessity of finding the center of pressure through which this thrust acts. The result is that experimental data are far from complete on the very points in which they are most wanted. If, however, we were to try and base our stability calculations entirely on the experimental data obtained for the separate aeroplanes, we should not only have a good deal of calculation to perform, but at the end we should have omitted to take account of the resistance of the framework, car, and rider. A simpler plan would be to construct a stabilimeter* for experimenting on models as a whole instead of with single aeroplanes. When a machine begins to pitch and rock it has a rotary as well as a translatory motion, and the rotation may, and certainly does, influence the magnitude and position of the resultant thrust of the air. No calculation of stability can be considered valid which does not take account of this influence. One might just as well neglect the wedges of immersion and emersion in working out the stability of ships. On this turning effect, as it might be called, we have no experimental data whatever. But if a model is to be tested in a stabilimeter, the mechanic will require simple working rules for applying his results, and these must in the end be laid down by mathematicians. In particular he will have to be told whether he can improve the stability of his model by altering the positions of his aeroplanes or the moment of inertia of his machine. A number of questions require answering, and the answers require putting in a simple form. Here is one example: In a dirigible the critical velocity represents the greatest velocity consistent with stability; in an aeroplane system it represents the least velocity. If, starting with a dirigible, we add aeroplanes and reduce the size of the balloon gradually down to nothing, we must come across an intermediate type which is either always stable or always unstable. What is this type?

The recent flights show what can be done in aviation by a person possessed of skill and experience. They are a necessary factor in the development of artificial flight. The problem is in quite a different position from what it was a year ago. But if flying-machines are to be made accessible to the million, the sooner aeronauts learn mathematics or get someone to do the mathematics the better. At the present time a great deal of rubbish passes off as mathematics which is quite unworthy of the name. We may instance the use of Taylor's expansion in infinite series to prove, not even that the reciprocals of a harmonical progression form an arithmetical progression, but that the general term of this arithmetical progression is of the form written down in elementary text-books on algebra.† Or, again, the discussion of the details of an example which would be in a more proper place in a school textbook or examination paper on elementary trigonometry.‡

Mr. Lanchester's book should open the eyes of many would-be aeronauts as to the complex theoretical investigations which have to be mastered in any attempt to reduce the problem of flight to an exact science. Although the author has purposely avoided, so far as possible, the use of mathematical formulæ, the reader who aspires to revolutionizing the flight problem without making actual experiments and without an extended study of mathematical or physical principles will find the book a pretty hard nut to crack.

The time has, however, passed when any useful purpose can be served by merely writing to the effect that the proper way of solving the problem of flight is by means of vertical screws or by imitating the action of birds' wings. When people can fly for an hour by one method they will scarcely be likely to try another. An actual demonstration of either of these alternative methods as applied to a man-carrying machine would, of course, be watched with considerable interest. Whatever may be the best and cheapest way of advancing aeronautical knowledge, it is probable that the human element and the feeling of "every man his own flying-machine" will appeal most to the Englishman, and more scientific methods will appeal more to the German, who has already arranged for translations of Mr. Lanchester's works.

Mr. Herbert Chatley* has directed attention to the part played by eddy formation in determining the flow of air in the wake of aeroplanes. This factor may introduce dangers in a flying-machine should the rate of eddy formation coincide with the period of free oscillation. Accidents from a similar cause have frequently occurred in other branches of engineering, and it seems very probable that some day we shall have an object lesson of the kind in aeronautics. But the study of these eddies affords an interesting recreation for those who like to look into the matter. The side of a ship is a good place for watching eddy formation, but a better place is a dusty road along which motor cars are passing. Here anyone can see the eddies being thrown off at perfectly regular intervals, each picking up a separate cloud of dust and whirling it high into the air. If the observer cared to carry his researches further he might get a motor car and try attaching tails of different sizes and shapes to it until he got one in which the eddy formation was reduced to the smallest possible amount, and the air resistance would probably be also reduced. He would not succeed in abolishing dust altogether, nor would he make a fortune by taking out a patent; but he would discover a more effectual means of reducing the dust nuisance than by writing complaints to the newspapers.—Nature.

AIRSHIPS AND WIRELESS TELEGRAPHY.

WIRELESS telegraphy tests have been made between the balloon "Condor," which ascended in the neighborhood of Brussels, and a station erected in the tower of the Brussels Palace of Justice. Morse signals sent from the Eiffel Tower, in Paris, were also clearly received by the balloon. That the German airship battalion has made extensive experiments with wireless telegraphy has been already recorded. The apparatus used were furnished by the Telefunken Gesellschaft. Several years age Prof. Hergesell of Strasburg made some telemechanical experiments with unmanned registering balloons. Attached to the same were small receiving stations which, upon the arrival of the electric waves, actuated a valve and caused the balloons to fall. Each balloon was attuned to a certain wavelength. Thus, it was possible for the vessel, from which the balloons were sent up, to bring down any one of them at will, while the others remained in the air. The experiment was successful up to a distance of ten nautical miles, and wireless communication between flying balloons and land stations was at that time already considered possible. But at the airship trials this year it was feared that, if wireless apparatus were taken on board, sparks might be generated, which would cause serious consequences by exploding the gas. However, recently it seems to have become possible to remove this danger and to guarantee a safe wireless communication between balloons.—Translated and abstracted for the Electrical Review from Elektrotechnische Zeitschrift.

The Moscow-Kieff-Voronezh Railway Company has submitted for sanction a definite scheme for the construction of a railway running about north-northeast from Odessa through the towns Voznesensk, Pomotchnaya to Bobrinskaya and Tcherkassy, where it will cross the Dnieper by a bridge about 1,100 yards in length. From thence to Bakhmatch there is a narrow gage line already laid, which will be widened. When the connection is complete the distance from Odessa to Moscow will be decreased from 943 to 733 miles. The distance to St. Petersburg will be decreased from 1,212 to about 1,066 miles. For the first 100 miles the line runs across wheat growing country, which has hitherto had no railway service, but has sent its products by way of the river Boug to Nicolaieff. It is probable that Nicolaieff will therefore suffer loss.

* See, e. g., Cassier's Magazine, June, 1901.
† Aeronautics, August, 1908, p. 61.
‡ American Magazine of Aeronautics, July, 1907, p. 8.
§ "Researches and Experiments in Aerial Navigation." By S. P. Langley. Reprinted from the Smithsonian Reports. (Washington: Government Printing Office, 1908.)

* Cornhill Magazine, May, 1907.
† Aeronautical Journal, April, 1908, p. 27.
‡ Aeronautical Journal, January, 1904, pp. 4, 5.

* Aeronautics, August, 1908.

THE HUMAN ENGINE.

HOW THE BODY TRANSFORMS FUEL INTO ENERGY.

BY DR. ANDREW WILSON.

THE idea that a good many analogies between machines of man's making and his own body are capable of being drawn is not one which prominently forces itself on the public view. Yet nature has preceded man in respect of "many inventions" which typify and foreshadow mechanical expedients seen familiarly around us. We have a force-pump illustrated in the heart, and a photographic camera—lens, adjustment, and so forth—in the eye. We find all kinds of lever-movements exemplified in the working of bone and muscle, and we could discover examples of self-governing machinery in the nervous regulation of the heart and circulation. Valves are also duly represented in the heart for the regulation of the blood-flow in the proper direction and for the prevention of back-currents; while the whole nervous system is nothing more than a very complex telegraphic apparatus, imitated even to its batteries, its wires, its instruments, and its switchboards.

So far, there is little difficulty in drawing many comparisons of exact nature between the furnishings of our bodies and the mechanical contrivances which characterize the march of civilization and human progress. But beyond these details lies another field of inquiry such as opens the door to considerations connected with our body and its working powers, viewed collectively as a living machine. A little reflection shows us that all through life the body of an animal, high and low alike, is the seat of constant change, and that this change is due to the fact that the living frame is incessantly at work. It is true that in the hours of sleep the bodily processes are slowed down; they do not, however, cease action. The heart works constantly; the rise and fall of the chest in breathing continue all through life; the process of manufacturing the fluids and secretions used in digestion (such as bile, sweetbread-juice, and the like) goes on both in sleep and in the waking state; and of certain brain and nerve centers it may truly be said that they exist in a condition of unending watchfulness, keeping watch and ward over the actions through which life is maintained. No truth of physiology is, therefore, more easily demonstrated than that which shows forth the constant work of the body. This inside labor is independent of the external work we perform; indeed, it is through the possession of the working powers just noted that we are able to perform the daily tasks our hands and brains require to discharge. Our body, therefore, is not merely a working engine in itself; its labors extend beyond the actions devoted to its upkeep, and include other duties through which the vast majority of mankind gain their daily bread.

Now, all work, whether in a watch, an engine, or a living body, implies wear and tear. There is represented waste of the substance of the machine; and there is seen waste—that is, the using up—of the "energy" or working power wherewith it is endowed. The watch wears, imperceptibly perhaps, but nevertheless surely, until in time renewal of its parts is demanded if its time-keeping functions are to be accurately performed; but every day the store of energy we impart to it by the coiling of the spring requires to be reinformed and renewed by fresh winding. The engine also wears down its parts, and equally demands fresh fuel as the source of its working power. The living body presents a striking likeness to both machines. Our substance wastes imperceptibly day by day; worn-out cells are replaced by new cells, and in time a complete reproduction of our tissues must take place, while our personality is wondrously maintained throughout the change. So also our store of "energy" is dissipated in work. We grow tired and weary, and hunger and thirst afflict us, and so we need sleep and food and drink by way of supplying us with fresh power to discharge the work our hands and brains find to do.

These facts raise the question in the case of the living machine of the value of different foods regarded in the light of sources of working power. Obviously this topic is of high social and economic interest. We should be able to select those foods which are best suited for energy-production, not forgetting that from our food we also require to draw material for the repair of the living machine itself. As a matter of fact, we do not make this distinction in the foods on which we subsist. We speak of "body-building" foods (those that contribute to tissue-formation and tissue-repair) and of "energy-producing" foods (those which give us the "power of doing work"). The former class includes such substances as meat-juice and white of egg (albumen), the curd or casein of milk, the gluten of flour, etc., the legumin of peas and beans and lentils, fibrin derived from blood, and like substances. The latter class is represented by fats, starches, and sugars, foods which are really nearly akin in chemical composition. Starch is changed into a sugar by the saliva of the mouth, and starch and sugar can be converted into fat, especially when the latter food (sugar) is taken in excess. In addition to these food elements we have, of course, to add water, minerals, and the oxygen breathed in from the atmosphere. These last are equally with the other items to be regarded in every sense as foods. While there is a very distinct line to be drawn between the body-building foods (called also "nitrogenous" foods because they contain the element nitrogen) and the energy-producers, it must be borne in mind that under certain varying circumstances of life the functions of the foods may become interchangeable. On occasion the tissue-forming foods may to a certain extent be employed in force-production. But apart from this fact, the characters of the two classes of nutriments, as evinced by their functions when consumed in the body, may be regarded as being clearly enough defined on the lines just noted.

The next point for consideration brings us face to face with a great scientific doctrine, that of the transformation of energy. Here we see illustrated the indestructibility of force. All that really happens is that energy merely changes its direction; it cannot be put out of existence. A bullet striking the target converts its motion, suddenly arrested, into an equivalent of heat. A weight dropped from a height also has its motion transformed into a corresponding amount of heat when it lands on the ground. All the energy of nature which man uses in the form of steam and electricity illustrates this same doctrine. The energy stored up in coal, when liberated, raises the temperature of water and produces steam, and this steam may either itself give us a certain return for the coal in working power, or it may be used to generate an equivalent of electrical force into which its energy can be converted when applied to the movement of a dynamo-machine. Now, the working power of the human engine has to be calculated on a precisely similar basis. All the power it develops it derives from its food. Whatever energy it exhibits represents as truly the transformation of that which was locked up in the diet into muscular and brain work, as does the liberation of the energy of the coal when burnt account for the work done by the steam engine. Accordingly, it has been found possible in science not only to estimate the relative values of the various foods which stoke the living machine, but also to calculate how much work day by day that machine, under ordinary circumstances, is capable of generating. Science, by the aid of the "calorimeter" (literally "heat measurer"), has succeeded in proving that the oxidation or burning of a given amount of food outside the body corresponds in respect of the heat generated with that produced by the chemical burning and consumption of such food within our frame. As the measure of a food's heat-producing power is to be taken as that of its energy-development, we can thus also calculate the amount of work which can be done on different foods, and likewise the body's working capacity viewed as a whole.

The standard by which we judge both things, on the English system—the foreign system differs somewhat—is founded on the "heat-unit." This is the amount of energy needed to raise the temperature of one pound of water one degree measured by Fahrenheit's scale. Now, if this same amount of energy were applied in mechanical work, it would raise seven hundred and seventy-two pounds weight one foot high, or (what is the same thing), one pound weight seven hundred and seventy-two feet high. We usually calculate work in terms of "foot-pounds" or "foot-tons." The latter unit is the amount of work required to raise one ton weight one foot high. As we have thus got a standard or unit, the calculation of the force-values of foods becomes experimentally easy. The fats, starches, and sugars are our great sources of energy, and are therefore to be regarded as our typical working foods. One calculation teaches that one hundred parts of fat are equal in value as energy-producing material to two hundred and thirty-two parts of starch, two hundred and thirty-four parts of cane-sugar, and two hundred and thirteen parts of the body-building albumen. The German army medical authorities were wise in their day and generation when they insisted on a large proportion of fat being included in the soldier's ration.

It may finally be asked, what power is the human engine capable of developing on the fuel with which it is supplied? This question can be answered with a very near approach to correctness—as near, indeed, as we can ever approach exactitude when dealing with the continually varying conditions of a living body. Man's bodily work is divisible into two categories. First, he has to produce heat, itself a large item in the working expense, and to provide power for the internal work of the frame. The heart has to be kept working, the muscles of breathing have to be provided for in the way of energy supply, and even the act of digesting food to repair the body involves the expenditure of energy, illustrating thus the burning of the physiological candle at both ends. The second phase of work done by the bodily engine is represented by that which is external—that is, the work of our muscles and the daily labor in which we may otherwise be engaged. The body's own energy expended in maintaining heat and in providing for the upkeep of its internal work has been calculated at about two thousand eight hundred foot-tons per day. Put into a big lift, so to speak, this amount of work would raise two thousand eight hundred tons weight one foot high. The external work on the same basis is given as amounting on the average to about three hundred foot-tons daily, while a very hard worker may develop from five hundred to six hundred foot-tons. But it would seem that even to get the bare outside work of the human engine done we need to develop actually about five times its amount, plus that needed for the internal work. So that if we are to allow three hundred foot-tons for the outside labor of the body, we have really to provide one thousand five hundred units, and to add to this the two thousand eight hundred required for the body's own affairs, making a grand total of some four thousand three hundred units to be generated every day we live.

Now, though these figures seem large, they nevertheless represent economical work when all is said and done. A man's total daily income of food, water, and air amounts to about eight and one-third pounds only; yet out of this modest supply his body generates power far exceeding in amount and in direct economic usage that produced by the best engines of his own invention. The waste seen in the engine, due to friction and to loss of power in getting at its work, so to speak, is largely obviated in man's own body. While only a small percentage of power for the coal burnt is returned to us by our finest engines, our own body yields a very generous amount indeed, having regard to its small fuel consumption. If we think that a man's heart alone, in twenty-four hours, expends one hundred and twenty foot-tons of energy—force sufficient to raise that weight one foot high—we may see how admirably living Nature orders her ways of income and expenditure. The profit, in the shape of "the power of doing work," we get out of our food and drink and air is really a very handsome one. Most wonderful of all is it for us to consider that all man's achievements, physical and mental alike, represent part of the profit accruing from the transformation of what he eats into what he does.—Chambers's Journal.

The amount of radium emanation in the atmosphere has been recently determined by two observers. Mr. J. Satterly has measured it near the earth's surface at Cambridge, by absorption by charcoal, and also by condensation by liquid air. The two methods give results in fairly close agreement; but show that the amount is not constant. The average value per cubic meter of air is the quantity which would be in radioactive equilibrium with about 10^{-19} gramme of radium. This amount (together with its disintegration products) would produce about 3 ions per cubic centimeter per second. As the number of ions actually produced per cubic centimeter per second is about ten times this, Mr. Satterly infers that only a small proportion of the natural ionization of the air is due to the presence of radium emanation and its products. Prof. A. S. Eve has also determined this quantity. His result for the neighborhood of Montreal is 0.6×10^{-19} gramme as the mass of radium which would be in equilibrium with the average amount of emanation in a cubic meter. The amount, however, was found to vary considerably, the greatest value being about seven times the least. The amounts in summer and in winter are not widely different, and large changes of temperature appear to have little or no direct influence on the quantity. Anticyclonic conditions with dry or very cold weather diminish the amount.—Knowledge.

USES OF CONCRETE ON A COUNTRY ESTATE.

THE ARCHITECTURAL POSSIBILITIES OF CEMENT.

BY LINN WHITE, C.E.

CONCRETE is admirably adapted to many purposes upon the modern country estate and it may be successfully used by the laborer of fair intelligence under proper supervision. But because it is a material easily handled, requiring only a few simple tools to prepare, it does not follow that successful results can be obtained without attention to certain rules and principles.

The materials must be selected and proportioned, having in mind the particular purpose for which the concrete is to be used. Also, consideration must be given to the kind of surface finish that may be in keeping with the character of the structure and surroundings. One would not build a piece of rubble stone masonry in the same situation or for the same purpose one would a piece of cut marble work, nor would it be done with the same careful attention to detail. Or to extend the case, a certain amount of skill and care would be exercised in building the rubble wall and the result would probably be satisfactory. If only the same skill and care were exercised in erecting the cut marble, the result would doubtless be very disappointing. Concrete can be varied as much in texture and composition as stone work, and each variation should have a definite purpose and reason. It is the intention in this article to give the necessary rules for the proper mixing and handling of concrete for ordinary purposes and to suggest certain structures and methods of finishing adapted to the inexperienced worker.

FIG. 6.—ANOTHER VIEW OF THE CONCRETE RESIDENCE OF MR. OLIVER AMES.

FIG. 7.—A GENERAL VIEW OF THE CONCRETE BUILDINGS AT GEDNEY FARMS.

Foundations, retaining walls, walls inclosing yards, paved gutters and roadways, paved beaches, boat landings, posts for gateways, pergolas, culverts, arches, basins for pools and fountains, curbs, steps, walks, floors, etc., are some of the various structures that find a place on the country estate. This list might be made much longer, but it is intended only to be suggestive. Various simple buildings might very properly be included, the walls of which, with the openings for doors and windows, are about as easily built as retaining walls.

The preparation of the foundation for a concrete structure is naturally the first thing to receive attention. Unless supported on rock, the foundations of walls, piers, arches, or other structures carrying considerable weight, either of their own mass or superimposed, should be carried below frost line, which in the latitude of Boston, New York or Chicago is from 3 to 5 feet deep. In warmer latitudes, where there is but little frost, such foundations should be at least 3 feet deep to insure stability. Good drainage, too, is desirable for all foundations. Sand, if confined, is unaffected by the presence of water, but clay softens and swells with excess of moisture.

Concrete pavement, even though only a few inches thick, may be safely laid directly on sand if well drained; but if the soil is clay, there should be a layer of clean, porous cinders, 6 to 12 inches thick, under the pavement. Under no circumstances should loam be permitted in the foundations of any concrete work.

Concrete is a mixture of stone, sand, and cement with water, combined in such proportions that the smaller particles fill the voids between the larger, making a practically solid mass. Either crushed stone or gravel may be used for the coarser ingredients, and clean stone screenings may be substituted for sand according to color or surface finish desired, or according to whichever is the most easily procured.

The stone, or gravel, and sand must be clean and

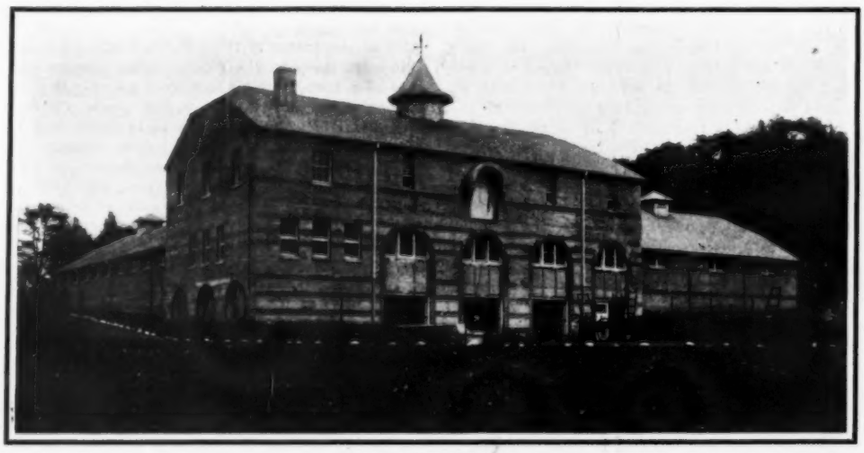


FIG. 8.—THE STABLE AT GEDNEY FARMS.

FIG. 9.—THE CONCRETE COW STABLE AT GEDNEY FARMS.

FIG. 10.—CONCRETE PIG PENS AT GEDNEY FARMS.

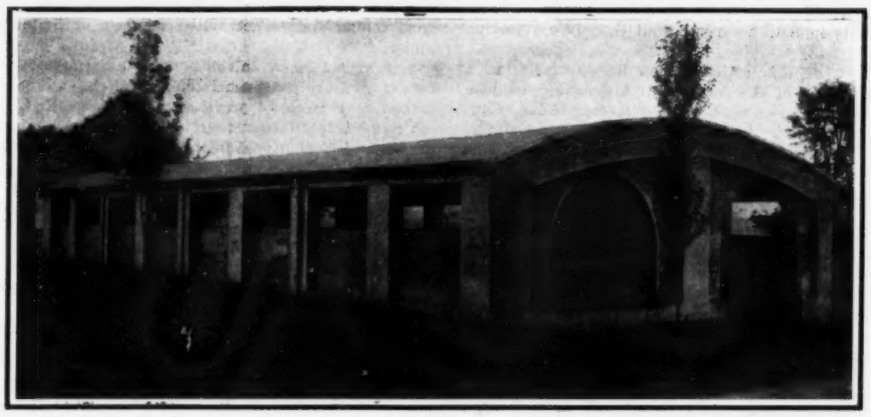


FIG. 11.—A CONCRETE MANURE SHED AT GEDNEY FARMS.

free from loam or clay. The grains of sand should be sharp and angular, not round and not very fine for most purposes. The sizes of stone or gravel may vary from ¼ inch in diameter up to the largest size used, which is limited by ease of mixing and handling and by the thickness of wall or other structure to be built. Stone 1½ or at the most 2 inches in diameter is about as large as can be handled conveniently with a shovel or as large as will hang together in the mortar. Therefore nothing larger should be used in concrete for ordinary purposes.

If the layer of concrete is thin, say 5 or 6 inches thick, as in a curb or walk pavement, the size of the largest stone should be limited to ⅞ inch. If it is desired to give a grainy, uniformly rough texture to the surface (a surface finish which is very effective in walls, posts, or columns, and which will be described further on in this article) the size of stone should be further limited to ¼ to ⅜ inch. Whatever size of stone is taken as the limit it should be uniformly graded in size from the largest stone down to the grains of sand. It is possible to find gravel with just the right admixture of sand, or to obtain stone from a crusher with the right proportion of screenings to make a good concrete, but it is seldom so found. Usually the fine material is in excess and must be screened out and recombined in the desired proportions.

Cement as sold and used for general purposes is of two classes, natural and Portland. Natural cement is made from materials found properly combined in their natural state. Portland cement is made by artificially combining the necessary materials which are burnt and ground to the required fineness. Of the two, Portland cement attains a greater strength and hardness within a limited period of time and is preferable for all kinds of finer work, especially when the masses are small, where there are exposed lines or corners, or where the concrete is much exposed to changes of temperature or the action of water. In protected foundations or in plain walls, where the masses are large, natural cement may be used satisfactorily. Natural cement is the cheaper of the two and under favorable conditions continues to gain in strength and hardness for years, while Portland cement practically reaches its maximum in one to three months. Either kind, when used in concrete, gains sufficient hardness to

FIG. 12.—THE CONCRETE DAIRY AND OFFICE AT GEDNEY FARMS.

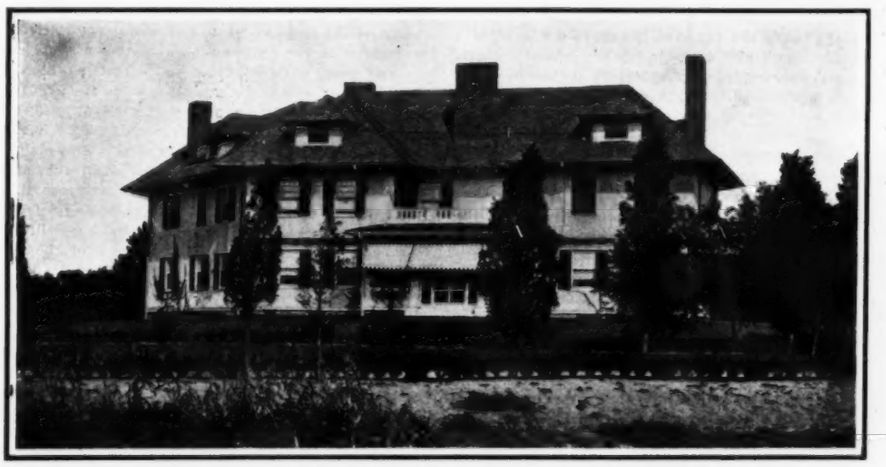


FIG. 13.—A CONCRETE RESIDENCE AT LAWRENCE, LONG ISLAND.

hold its own weight and permit the removal of forms in 24 to 48 hours under ordinary conditions.

Portland cement has grown greatly in popularity during the last few years and is better suited for miscellaneous uses. Therefore it will be understood as the kind referred to in this article.

The proportions of the ingredients in concrete suitable for foundations and work where the masses are considerable, are one of cement, three of sand or stone screenings, and six of stone or gravel (1-3-6). If it is desired that the concrete shall be watertight or be without the appearance of voids or unsightly rough places on the surface, the proportion should be 1-2½-5 or 1-2-4. This gives an excess of fine material in the mixture and insures that the larger particles of stone shall all be well bedded in the mortar. It also makes a stronger concrete, especially where the masses are small.

Concrete made with gravel instead of crushed stone is a little more compact and a little more easily mixed, because the rounded pieces of gravel are more easily pressed together than the angular fragments of stone. It is therefore better for dams or basins intended to hold water.

FIG. 14.—CONCRETE SILO AT GEDNEY FARMS.

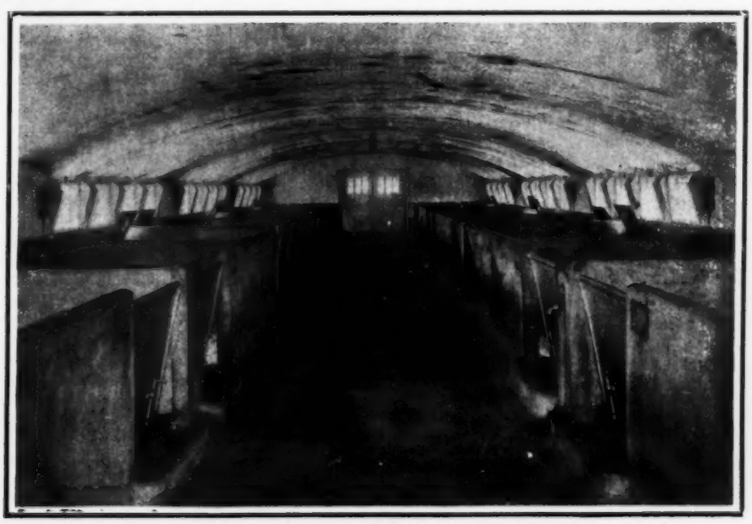


FIG. 15.—CONCRETE PIG PENS AT GEDNEY FARMS.

THE USES OF CONCRETE ON A COUNTRY ESTATE.

The mixing of concrete is best done on a tight platform of boards approximately level. A platform 8 feet by 10 feet is large enough to mix a cubic yard of concrete. Where only three or four men are engaged a smaller platform will do, mixing a proportionately smaller quantity of concrete. Spread the sand on the platform and the cement on top of it. Mix dry by turning with shovels, throwing it in a heap in the center of the platform and again spreading, repeating this process two or three times until the whole mass is of even color. Spread the mixed sand and cement and sprinkle with water from a hose or large sprinkling can, turning it with shovels or hoes until the whole mass is of the consistency of mortar. Again spread it and add the stone, which should be first sprinkled. Turn the whole mass with shovels or hoes until it is thoroughly and evenly mixed, every stone being covered with and imbedded in the mortar. More water should be added from time to time during the mixing if needed to bring it to the desired wetness. As to the amount of water to be used considerable judgment and thought must be exercised. Wet concrete flows more readily into corners of forms, is more easily compacted and is more dense than dry concrete. It sets more slowly, however, and carries an excess of water, which in escaping is sometimes objectionably sloppy and is also liable to carry away with it some of the cement, leaving rough porous places. A concrete that quakes like a jelly when being rammed, and is just too stiff to flow, is about right for most purposes. For special reasons it may be made wet enough to flow when molded work is being done or a specially difficult form is being filled.

In placing concrete in forms it should be in level layers of even thickness, not exceeding 8 or 10 inches. It should be rammed with iron or wood rammers of from 8 to 12 pounds weight, or, if quite wet, it may be settled in place by churning it with spade or shovel. To insure a smooth surface when the forms are removed an ordinary spade may be used, forcing it down in the fresh concrete with the back of the spade next the face of the form, working it back and forth, forcing the large particles from the surface and leaving a space, as it is withdrawn, for the mortar to flow in against the face of the form. This is the most commonly practised method of getting a smooth, solid surface, but it is not uniformly successful because the concrete is not always of the same consistency, an excess of coarse stone may accumulate in one place without enough mortar, and even if well done every line and imperfection in the planks of the forms is reproduced in the concrete. Other methods of finishing concrete surfaces will be described below.

The building of forms often amounts to a considerable portion of the cost of concrete work, therefore it is advisable to study out the simplest method of construction, but it does not pay to use the cheapest lumber nor to take any chance on lack of strength. All lumber should be dressed on one side and should be free from rough or unsound knots. For first-class work it pays to have tongue and grooved plank, and for any considerable mass it should be 1¾ inches thick. If the lines are curved it is better to use thin boards with more frequent supports. Sometimes forms are lined with galvanized sheet iron or oil cloth. The sheet iron prevents the imprint of joints of boards or other similar defects in the surface of the concrete. The oil cloth prevents the grain of the wood showing in the finished surface but does not prevent the lines of joints appearing. There is danger, too, of its being torn or forming wrinkles, and is likely to leave a stain in the concrete surface. To obviate the adherence of the forms to the concrete they should be smeared with oil, soap, vaseline or some similar substance. Oil often leaves a stain and should not be used on first-class work.

Walls may be built to retain a fill or simply to inclose a space, as a garden, court or barnyard. Retaining walls require mass to keep from being overturned by the fill behind. The average thickness should be about one-third of the height above the ground line, which should be increased if the fill is likely to contain very much water. Usually there is a batter either to the face or back of the wall, thus a wall 6 feet high would be 30 inches thick at ground line and 18 at top, the average being about 24 inches. Unless the foundation is exceedingly good the base should be further spread to say 36 inches. Owing to the overturning tendency of the fill behind the wall the pressure on the foundation at the front line of the wall is the greatest and this part of the foundation should be especially good.

Pieces of small tile pipes should be put in for drainage or "weep" holes through the base of the wall every 40 or 50 feet.

Joints through the wall should be made about 40 feet apart, otherwise a small settlement or shrinkage will cause cracks.

Walls that do not retain a fill may be made any desired thickness, but when less than 6 inches thick, should be made of small stone, and when more than 3 or 4 feet high, should be strengthened by pilasters. Even greater care should be taken to provide plenty of joints in a thin exposed wall than in a retaining wall.

Fig. 3 of this article shows a wall inclosing a service yard of the following dimensions: Foundation 3 feet below surface and 2½ feet wide, height of wall 10 feet. Pilasters 20 by 24 inches, 40 feet apart. The wall between pilasters is 12 inches thick with sunk panels 2 inches deep. A coping of green Spanish roofing tile gives an appropriate finish to the gray concrete wall. The tile are 17 inches long on the wall, and on the pilasters two tile are used, one 17 inches and one 12. In the top of the wall is imbedded a 2-inch by 4-inch scantling to which the tile are fastened. The wall would be about as effective in appearance without the sunken panel, especially if it were lower, in which case it could be made thinner. At each pilaster is a joint made in the following way: The pilaster is built up first with vertical grooves in each side 4 inches deep by 6 inches wide. The boards forming the groove are then removed and the wall

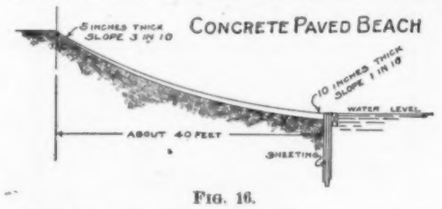


FIG. 16.

forms filled with concrete, at the same time, of course, filling the groove, which is first lined with heavy paper.

A very effective surface finish for any kind of wall may be made as follows: Make a facing mixture 1 of cement, 3 of stone from ¼ to ⅜ inch in size, and 3 of stone screenings. Mix quite dry and "crumbly." Set a board up inside the form two or three inches from the face, fill in front of board with the facing material and back of it with the concrete of which the body of the wall is to be made, which may be the 1-3-6 mixture. Lift the board out and tamp thoroughly; continue this process layer by layer until the whole wall is built. Finish the top with a 1½-inch layer of mortar, one of cement to three of screenings, struck or "floated" off level with top of form. After the mortar has begun to stiffen, trowel off vigorously and smoothly with a plasterer's trowel. When the forms are removed the surface will be of a uniformly rough and somewhat honeycombed texture, of a soft gray color, very agreeable to the eye, and will not stain readily. The joints and other small imperfections in the wood forms will not be reproduced in the concrete. It is very important to mix the facing material uniformly and of the same wetness. It should be crumbly and just too dry for mortar to be forced out of it by ramming.

While the above description is intended for retaining walls, this finish is equally well suited to walls for inclosures, buildings of simple design, gate posts, plain columns, in fact to almost anything except pavements and structures where there is much detail or where the concrete is expected to be waterproof. In thin walls or columns it is not practical to use the

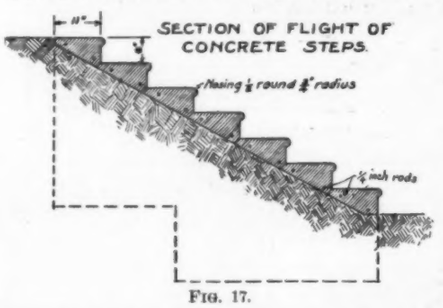


FIG. 17.

separating board, so all the concrete should be of the same mixture.

Another method of finishing walls to show a gravel surface is as follows: Build the forms with the undressed side of the boards next to the concrete. Plaster the forms with clay about ¾ inch thick. Do this plastering immediately ahead of the concrete, and, while it is soft, take handfuls of clean gravel and clap it into the clay plaster until it is well covered with adhering gravel. Place the concrete immediately, mixed rather wet, and tamp carefully so as not to disturb the clay and gravel. When the forms are removed most of the clay will come away with them, leaving the gravel imbedded in the mortar of the concrete with one clean surface exposed. Any clay adhering to the surface can be washed off. The clay will stain the concrete where exposed between the gravel, bringing it all to an agreeable gravelly tone. The gravel should be round and water worn, varying in size from ⅜ to 1½ inch, and so much the better if there are contrasting colors. This sort of wall looks best with a plain concrete coping and is not suited to posts or building walls.

A third method of finishing concrete surfaces is as follows: Place the concrete moderately wet and spade the surface as previously described. Remove the forms before the concrete is fully hardened, while it can still be indented with the finger nail. With wire brush and water scrub the surface until the faces of the stone or gravel are exposed. The best effect from this treatment is gotten by using stone or gravel of dark or contrasting colors. It is suited to almost any sort of structure with simple lines and without much detail.

The construction of the flight of concrete steps shown in Fig. 17 is shown in the following section.

The risers and ends of these steps are faced with mortar plastered on the form before the concrete is placed. The treads have a trowel finish made as described under the head of walks. Under the ends and center of the steps are foundation walls 12 inches thick with a minimum depth of 3 feet. The posts are 12 inches square with a molded cap and ball on top. The posts and ball are made with ½-inch stone mixed dry, as described elsewhere in this article, of proportions 1-3-3.

A beach for the protection of the bank of a stream or other body of water may be built as follows:

The face of the beach next the water is made of wooden sheeting driven down as deep as can be done by hand, with a waling piece bolted on at the water level and the tops of the sheeting cut off flush. The sheeting should be made of three thicknesses of boards spiked together with the center piece set to one side to form a tongue and groove on each piece. The bottom of each piece should be pointed with a cut on one edge, so that in driving, the point will be continually forced against the previously driven piece.

The concrete (of 1-2½-5 mixture) should be placed moderately wet and thoroughly tamped, forcing a layer of soft mortar to the surface. Over the surface, while still fresh, spread a layer of coarse sand or small gravel and lightly tamp. In this way it may be made to resemble closely a sand or gravel beach formed by the natural action of the water. It should be curved in section with a slope next the water of about one in ten and at the upper edge three in ten. The thickness of the concrete next the water should be 8 or 10 inches and 5 or 6 inches at the upper edge. It should be cut into blocks like the driveway described below.

One of the most common and useful applications of concrete is in the construction of pavements and curb. A first-class smooth-finished pavement suitable for walks or floors may be made as follows: Prepare a well-drained foundation of coarse sand or clean cinders 12 inches thick, thoroughly compacted by flooding with water and tamping or rolling. Set strips 2 inches thick by 5 inches wide supported by substantial stakes, to outline the walk, with similar cross strips, so it will be cut up into flags not exceeding 6 feet by 8 feet in size. Set the strips so that the tops will be at the exact grade of the finished surface of the walk. Place a layer of concrete in every alternate flag, of 1-2-4 mixture, and tamp thoroughly so that the thickness after tamping will be 4 inches. While it is still fresh spread a layer of mortar and with a straight edge strike off level with the top of the strips. The mortar should be one of cement to two of coarse sand made rather wet, so that it may be readily struck or floated off with the straight edge. After the mortar has begun to set and is just stiff enough when cut into with the trowel not to flow back and close the cut, trowel the surface over smoothly and vigorously with a rectangular plasterer's trowel. This troweling should be done thoroughly and carefully until the surface is quite compact. A little experience will teach the workman when the mortar has set sufficiently to give the best results. It must be too stiff to flow or travel in front of the trowel, and the object is to compact the mortar as well as to smooth the surface. Sometimes a little dry cement dusted over the surface aids the smoothing process if the mortar is too wet. If too dry brush the surface with a whitewash brush dipped in water. The trowel should be dipped in water frequently to keep it bright and clean. The exposed edges of the walk should be rounded off with a small tool shaped like a trowel with a curved face. After troweling, brush the surface well with water and protect from sun or rain until set. After finishing the intermediate flags as above, remove the dividing strips and lay the remaining flags in the same manner. Joints between flags should be made with strips of building paper put in against the dividing strips before the first flags are laid. About every 30 or 40 feet a board ½ inch thick should be inserted in the place of the paper, or, better, between two strips of paper, to provide an expansion joint. After finishing the pavement and before it is thoroughly set, carefully remove the board. The open joint may be afterward filled with sand. Floors in buildings or bottoms of pools or basins may be laid and finished in the same way, only in buildings where the changes of temperature are not so great

there is not the same need for expansion joints. The open joints in pools or basins may be filled with hot pitch or paving cement and calked with a blunt chisel as it cools.

Curb should be built and finished in a similar manner, the vertical exposed face being faced with a coat of mortar plastered against the inside of the form before the concrete is placed. Curb should be built in alternate sections about 6 feet in length with the exposed corner rounded off to a radius of one inch. The thickness is usually 5 or 6 inches and the depth in well-drained sandy soil 24 inches, but if in clay it should be 36 inches with from 6 to 12 inches of cinders or coarse sand in the bottom of the trench under the concrete.

Pavements built as above will stand heavy, constant travel. For ordinary light service the finishing coat may be reduced to ½ inch and the total thickness to 4 inches.

Pavements for driveways should be made in a similar manner, but the thickness should be from 6 to 8 inches. At the same time the mixture may be made a little leaner, say 1-2½-5. Across the drive make shallow grooves, ½ inch wide by ¼ inch deep 3 inches apart, to provide a foothold for horses. Instead of the mortar surface a finish may be used composed of 1-2-2 concrete with the largest stone or gravel not exceeding ½ inch in size. Tamp the finishing layer thoroughly by laying down a board and tamping on top of it and finish with a hand roller, sprinkling the surface in front of the roller with coarse sand. The blocks or flags in which the pavement is divided may be made much larger than in the mortar-finished pavement.

In all concrete work the material should be handled and placed promptly after being wet and before it has begun to stiffen. It contracts as it sets and also expands and contracts with every change of temperature, and for these reasons requires expansion joints. If the surface is protected from the sun or from too quick drying out by sprinkling and covering up, hair cracks may be prevented.

When work is left uncompleted over night or long enough to set, the surface should be thoroughly cleaned and washed and brushed over with a coating of neat cement grout before applying fresh concrete.

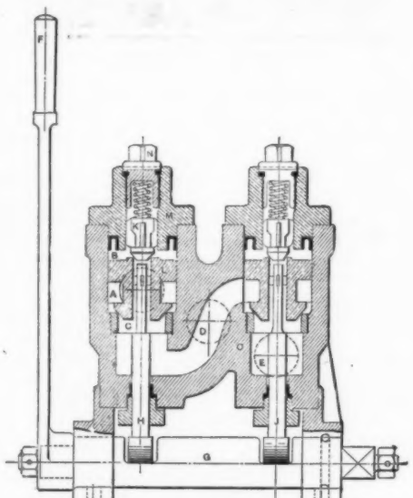
If concrete is laid in freezing weather, it should be well protected from the action of frost.

HYDRAULIC VALVE OF ENGLISH DESIGN.

AN INGENIOUS WAY OF CONTROLLING HIGH PRESSURES.

A CATALOGUE issued by an English firm describes a design of hydraulic valve for high pressures and large volumes that is ingenious enough to warrant some attention. A cross section of the valve is shown in the accompanying line engraving. In the case shown, there are two valves with an inlet at *A*, a connection at *D* for the hydraulic cylinder to be operated, and an outlet at *E*. These valves are operated by a handle connected to rock-shaft *G*. Throwing it in one direction opens the inlet valve at *A*; throwing it in the other allows the water to escape from *D* through outlet at *E*.

The valve stems *H* are raised by cam surfaces cut in the upper side of rock-shaft *G*. The stems do not directly open the main valves; the upper end of a stem passes through main valve *L* in a hole large



A HYDRAULIC VALVE WHICH IS CONTROLLED BY THE OPERATION OF A SMALL PILOT VALVE.

enough to allow it plenty of clearance, as shown, and when raised, it strikes against the bottom of pilot valve *K*, which it lifts against the pressure of the spring above it and against the pressure of the water in chamber *B*. Chamber *B* is filled with water leaking from inlet space *A*, past the easy fit of the piston portion of valve *L* between them. As soon as *K* is raised, the pressure in *B* rapidly drops to that in service connection *D*, since the outlet through the center of the main valve is much larger than the area through which the leakage escapes from *A*. Under these circumstances there is an unbalanced pressure on valve *L* from the water in *A*, which forces it from its seat on ring *C*. This unbalanced pressure is obviously due to the fact that the piston portion of main valve *L* is much larger in diameter than the seat on which it rests in ring *C*.

In closing, the reverse of this action takes place. The handle being brought back to its central position, valve stem *H*, and with it pilot valve *K*, are lowered until the latter reaches its seat in valve *L*. Connection between *B* and *D* being thus closed, the leakage from *A* into *B* allows the pressure in the latter space to rise until it balances that in *A* when the coil spring has sufficient pressure to force valve *L* down against its seat. The two valves are identical in construction and operation.

This construction evidently has a number of advantages. The use of the small pilot valve, the only member which has to be lifted against the full pressure of the water, makes the apparatus more easy to handle than would be the case if the whole main valve *L* had to be raised from its seat against the full pressure. Another thing is the ease of action obtained, without the excessive use of lubricants in the water. This is due to the fact that there are no sliding movements to be effected through packings under heavy pressure; the valve stem *H* is not under pressure until the valve is opened. Another item is the absence of leather or other packings, placed where it is difficult or impossible to detect leakage past them. Packing is provided for plug *N*, cap *M* and valve rod *H*. All of these, it will be seen, pack against the atmosphere. It will also be noted that both the main and pilot valves can be easily reground without breaking any of the hydraulic joints. There would appear, also, to be little danger of shock from sudden closing of the valves, since the lowering of main valve *L* to its seat on *C* is effected by the leakage from *A* to *B*, which can be made as gradual as seems advisable, being regulated by the fit of *L* in its cylindrical chamber in main casting *O*.—Machinery.

A NEW MARINE HYDROCARBON ENGINE.

A NEW type of Sulzer-Diesel oil motor has been designed for marine use. At present the gasoline motors which are used for marine work are of the well-known type of stationary motor which have been adapted to this purpose, but still keep their qualities of fixed motors. A reversible marine motor after the manner of a steam engine and coupled direct to the propeller, whose direction of rotation and speed can be changed with ease, has not yet been constructed. The new Diesel motor has a very low fuel consumption, this being a heavy oil and is burned at the rate of 200 or 250 grammes per horse-power hour, as compared with 330 to 500 grammes for other gasoline engines and 1,000 grammes for the coal of a steam engine. In the present motor petroleum residues are burned as well as other oils which are not sufficiently inflammable to be used in ordinary gasoline motors. From a mechanical standpoint, while other motors must be provided with a special mechanism for giving the reversal, either a reversing clutch or screw with movable wings, the present motor is self-reversible. Some gasoline motors have been built as reversible, having 6 or 8 cylinders working on the same shaft, but they must be uncoupled by the clutch before reversing and are then recoupled to the propeller when the motor is started up, inasmuch as these motors cannot start when under load. This makes it impossible to use such motors with a high power. When uncoupling the motor, it is likely to race, and during the operations of the clutch mechanism which take some time, we have no control over the propeller.

The new motor is of the two-cycle upright type and has four cylinders so as to assure the starting in any position and to reduce the weight of the flywheel. Three steel reservoirs are used for the compressed air. This gives a supply for 20 starts of the motor even if the tanks are not filled by the air pump. An oil pump brings the fuel to the motor and gives an automatic feed. The exhaust is nearly silent and the gases are invisible, except at starting. In this case the propeller is mounted directly on the motor shaft. Not counting the propeller and its shaft, the weight of the complete motor is from 60 to 100 pounds per brake-horse-power. The engine can be constructed in sizes varying from 100 to 1,000 horse-power.

The latest development of the policy of the Forest Service at Washington is the projected establishment in the West of a number of forest experiment stations, which, it is anticipated, will do for American forestry what the agricultural experiment stations have done for the country's farms. The first station of the series has been established in the Conconino national forest, with headquarters at Flagstaff, Arizona. Here special attention will be paid to a study of the reproduction of the Western yellow pine and the causes of its success and failure. One of the most important functions of these stations will be the maintenance of model forests, typical of the region, as object lessons for foresters, lumbermen, etc.

A MACHINE FOR MEASURING THE PRESSURE EXERTED ON THE RAIL BY EACH WHEEL OF A LOCOMOTIVE.

DENISON & SON, of Leeds, England, have constructed a machine by which the pressure exerted on the rail by each wheel of a locomotive can be determined. The

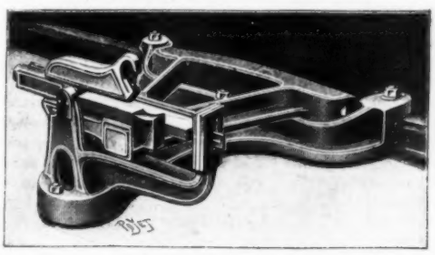


FIG. 1.—A MACHINE FOR MEASURING THE PRESSURE OF WHEELS ON RAILS.

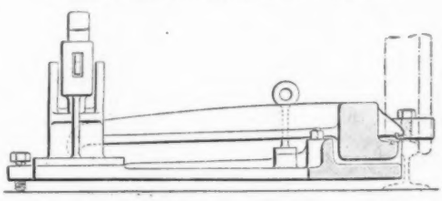


FIG. 2.—VERTICAL SECTION OF THE APPARATUS.

pressure is indicated in tons and hundredweights on a steelyard which is quite similar to those of ordinary platform scales. The novel part of the machine is the apparatus by which the downward pressure of the wheel is transmitted to the rod which communicates it to the steelyard. This device consists of a V-shaped frame of steel and a steel lever of similar form, but with its ends connected by a cross-bar. The apex of the frame rests on the roadbed between the rails and its ends are supported by screw bolts, the lower ends of which rest on the rail in front of and behind the locomotive wheel. The wheel, therefore, stands between the legs of the V. The triangular lever is narrower than the frame. Its apex rests on the frame, near the apex of the latter. Its base grazes the inner face of the rail and is supported by two knife edges, directed downward, which bear on smooth surfaces near the ends of the legs of the frame. At the middle of the base and directly under the part of the wheel that projects inside the rail is a third short knife edge, directed upward. All three knife edges are parallel to the rail and nearly in line with each other, the middle knife edge being a little farther from the rail, or nearer the middle of the track than the others.

The frame and lever having been properly adjusted, the ends of the frame are raised by screwing down the bolts which traverse them and bear on the rail. As the ends of the frame rise they press upward on the lateral knife edges and lift the wide or rail end

of the lever, causing the middle knife edge to bear on and lift the wheel from the rail. The weights on the steelyard are then adjusted until the traction on the tie rod is sufficient to raise the narrower end of the lever from the ground and the weighing is conducted in the usual manner. The wheel is now let down on the rail by unscrewing the bolts and the apparatus is adjusted to another wheel. This ingenious machine is made to weigh up to 10 tons and to accommodate wheels of diameters as large as 6 feet. It is so constructed that it can be tested in a vacuum, in order to verify its indications.—La Nature.

WOLF-SPIDERS.*

AN INTERESTING INSECT OF PREY.

BY RICHARD HANCOCK.

THE Lycosidæ are a group of exceedingly well-proportioned spiders most commonly seen running about on or very near the ground, on the grasses and low-lying plants. Let us try to capture one, and we soon find out that the spider nine times out of ten defeats

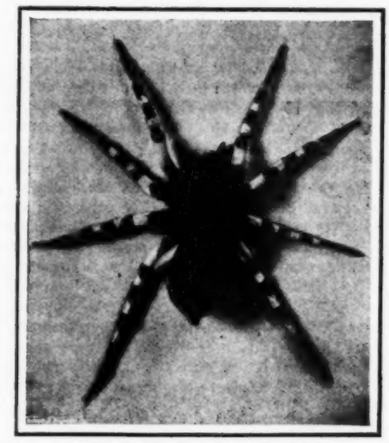
FEMALE AND MALE TARANTULA OCULATA.

us in our object, the hand and eye being too slow of movement for these wary creatures. From the Arctic regions to the tropics they are to be found, roaming over the earth's surface like miniature wolves, true to their name, capturing their prey by fairly and squarely running it down. Throughout the world there are described and recorded many hundreds of species belonging to this family. Although perhaps they do not arrest the eye as do the orb-weaving spiders (from the form of the snare), when structurally considered, the weaver undoubtedly falls short of the wolf-spider, and, indeed, many of the other groups. Their weak cephalo-thorax (head-chest), small jaws, comparatively small eyes and heavy abdomen make them take rank below the wolves, the leapers, the tunnel and the line-weavers. Although the construction of the orb-web is of a very high order, for in the making of it are combined the guiding principles of builder, architect, and engineer, yet to those who have studied well the snares of some of our line weavers, and the beautifully-constructed trap-door nests of some of the tunnel-weavers, the same beauty of construction is manifest. In my opinion, if both the spider's instinct and anatomical structure are taken into account (as it seems to me they undoubtedly should be), in the consideration of its systematic position, then the Lycosid would rank first in order.

Its colors harmonize well with its environment, generally of neutral grays or browns, with very few markings of a distinct pattern. In some species, as in the *Lycosa hellenica*, which is found commonly in Southern Europe and the Western Asiatic Peninsula, the markings are somewhat striking, with strong contrast between the light and dark parts, and in some species the markings are brighter on the under side than on the upper. The males, as is generally the case throughout spider life, are smaller in size, less voracious and cunning than the females. The fourth pair of legs are the longest, giving him an increase in speed, and an advantage over many of his brothers, an advantage he is not slow to turn to account. Born to fight for their very existence and means of living, they wage a relentless war one against another, the weaker going to the wall, or, rather, shall I say, providing a good square meal for the victor? Although cannibals in the highest degree—cannibals worse than any of the lowest types found in the South Sea Islands—relentless to their own species, even to their partners in life, they have a better side to their nature, making the most devoted mothers, and in time of danger defending their progeny to the last. Do not for one moment let it be thought that the wolves only wage war in their own camp, in their wanderings abroad they prey on innumerable flies, wasps, beetles and other small insects they come across. Some are to be found running about in search of prey during the day; but many species, as in the one photographed, keep in their cylindrical burrows, and with the twilight of the setting sun emerge from their holes, ready, thirsting for the fray. As the evening shadows lengthen, another Arachnid, in the form of a scorpion, comes out of its hiding-place beneath some stone or rock crevice and wages war on this particular spider. An unequal battle, with but one end for the spider—death. Can the spider hope to come out of the contest a victor with such a monster, protected as the scorpion is with his horny coat of mail and two such powerful pincers, which he knows full well how to employ? These Lycosids are very agile in their movements, progressing by short runs and leaps, and will often go considerable distances away from their burrow in pursuit of prey, indicating by the easy manner in which they find their home again after a hunting expedition a good memory of location or sense of direction.

The male and female *L. hellenica* pair during the month of May, and in August the female deposits her eggs, which number several hundreds, on a circular cushion of silk which she has made, after which she pulls the edges of the silk together, rolling it round the egg mass, and, spreading upon it an outer layer of silk, forms a beautiful cocoon. The whole of the eggs are deposited and the cocoon made within the space of a few hours, so quickly does she do her work. This is the critical period of her life, and before deposition of their eggs all Lycosids seclude themselves in a burrow or cave which they themselves form under the ground. Unlike many spiders, which abandon their cocoons as soon as deposited, and shortly after die, she attaches to it the under side of her body, lashing it to her spinnerets and, holding it tightly between her hind legs, carries it about with her wherever she goes.

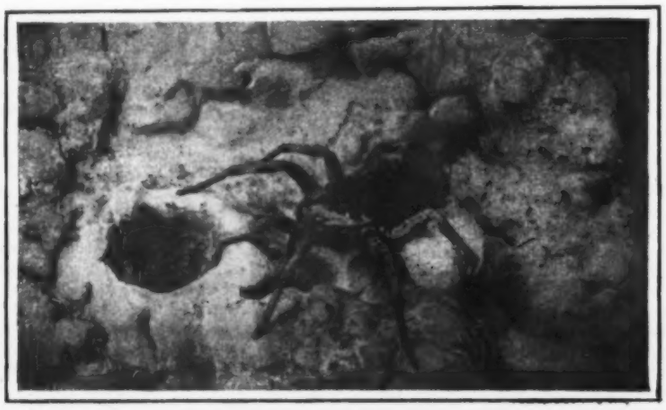
It seems remarkable that with so large an encumbrance as the cocoon she should be able to get about so readily and with such speed as she does. In the



UNDERSIDE OF FEMALE.

beginning of September the young *L. hellenica* emerge from the cocoon and climb on their mother's back, all seeming ambitious to reach the highest point, jostling each other in their various efforts to be at the head of the heap. Patient and long-suffering mother! Could not some of us take a lesson from her? Not only do the young cover the whole of her back, but they have the audacity to wander over the head, completely covering the eyes, when she will, with her fore legs, scrape off a few, only to let them clamber up again to take up fresh positions a few moments afterward. At this stage they remain on the back of the mother for about twenty days—wherever she goes they go too. They do not all leave the mother at the same time, but go off in detachments, like the scouts of an advancing army, and by this time, having done her duty well to them, the mother is anxious to cut them adrift. The young in their early stages of life are not nocturnal in their habits, as their parents, but roam about during the day, taking a good survey of their surroundings before settling down to an altered life and building their own cylindrical burrows, which they do when about three months old. The young Lycosids are addicted to the habit of ballooning; climbing to the top of some branch or fence, turning their head in the direction of the wind, with abdomen raised high, they throw out a thread which is pulled out by the force of the wind. When it is sufficiently long enough to sustain the spider's weight it casts itself adrift, sailing off on the wings of the wind to fresh fields and

* Abstracted from Country Life (London).



FEMALE WITH HER YOUNG.

FIGHT BETWEEN SCORPION AND SPIDER.

pastures new, maybe far from its parents' home.

When excavating their burrows they make pellets of earth in their jaws, which they bring up to the mouth of the tube and kick away with their feet. From the first they make their burrows larger than they seem to require, so as to allow of their growing, so doing away with the necessity of building larger from time to time as they increase in size. The burrows are of considerable depth, often extending to over a foot. They change their skin from time to time, the first taking place within the cocoon, and the second moult often while on their mother's back. Before their span of life is over they change their coat some nine or ten times, living as long as three years if fortunate enough to escape the pursuit of scorpions, their inveterate enemy. During the winter they hibernate, and when the cold nights come round many die in their burrows, those which escape being the fortunate ones which have chosen as a site for their nest some sunny slope facing the south, maybe under a bush, protected from the cold north wind. One of the greatest enemies spiders have to contend with is a species of hymenopterous (wasp-like) insect, which lays its eggs in the cocoons, and whose grubs when they hatch feed on the eggs of the spider. It is probably for this reason that the female so religiously guards her treasure and clings to the cocoon night and day. With some few species, however, the female, after having deposited the eggs, just before the time has arrived for the young to hatch out, forms a silken dome-shaped nest, in which she resides for a time with her numerous family, helping them in their early days to get their own living. Some carry the cocoon in their jaws held by their palpi, small leg-like feelers attached to their lower jaw, while others hold it between the abdomen and sternum, having to straighten out their legs as far as possible to carry their body high. Some species are found in abundance in marshy places and in the neighborhood of water, being able to run on its surface and dive down into its depths in search of prey, remaining under for nearly an hour. Many lead a vagabond sort of existence, and, like wandering gipsies, roam from place to place, with no permanent home or hiding-place, miniature tramps in the lanes and byways, some days rolling in luxury, on others knowing not where to get a meal. Others are as skillful in making an abode as the trap-door spiders, forming nesting burrows very similar in character to those of the last named. The turret spider (*L. arenicola*), found in many parts of America, builds a little turret of sticks and stones at the mouth of its tube, while another American species (*L. carolinensis*) builds a funnel-shaped tube at its entrance, concealed in the grasses around. One interesting species found in Russia (*Tarantula opifex*) builds a trap door to its tube; the lid, composed of layers of silk and dirt, being made thin toward the hinge and thicker in front, falls to its own weight. As with the nests of the trap-door or tunnel-weaving spiders, they vary in form between a single tube and the exquisitely-constructed silk-lined burrow having a hinged lid. At the commencement of winter the Lycosids often seal up their burrows with silk, keeping them closed until the spring, when they emerge with renewed life and energy after a long hibernation. The well-known *Lycosa tarantula* of Southern Italy, around which so many fables and yarns have been spun, is an allied species to the Lycosid, whose life history I have attempted to describe.

TWO REMARKABLE SENSE ORGANS.

A HEAT-FEELING EYE AND A SEARCHLIGHT EYE.

BY DR. WILHELM ROTH.

EVEN more remarkable than the gradual evolution of so important an organ as the eye from a very rudimentary form to the perfection which it attains in the human species is the fact that certain lower animals possess very elaborate organs which closely resemble the eyes in anatomical structure but perform functions that are yet little understood. These organs, which are of two distinct types, are found in certain cuttle fishes that live in the depths of the Mediterranean Sea.

One of these organs, which has been called a thermoscopic eye, is shown in section in Fig. 1. It is a globular body, covered by a protuberance of the epidermis *E*, and consists of a mass of large transparent cells *T*, a bundle of nerves, and a lens-shaped body *L*. This lens, however, is not transparent. On the contrary, it is so filled with black pigment that it is evidently quite opaque to luminous rays. Hence this organ cannot be an organ of vision but, as black substances possess great power of absorbing radiant heat, Joubin has expressed the opinion that it is an organ of heat perception. Indeed, the layers of flat cells behind the lens bear suggestive resemblance to the elements of the thermo-electric pile, which is exceedingly sensitive to radiant heat. But we are quite "in dark" concerning the possible use of such an organ to a creature living in the ice-cold depths of the sea in almost total darkness and also possessing two highly developed eyes of the usual type.

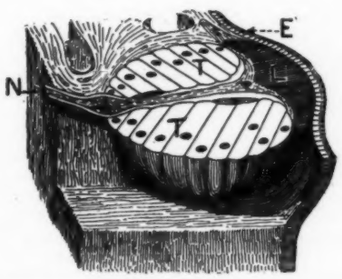


FIG. 1.—THERMOSCOPIC EYE OF A CUTTLE FISH (CHIROTEUTHIS BOMPLANDI).

We know a little more of the function of the second eye-like organ (Fig. 2), the structure of which indicates that it is a lantern designed for the generation and projection of light. Here, as in an eye, we see a lens (*L*), a transparent mass (*K*), corresponding to the vitreous humor, a layer of cells (*Ph*), corresponding to the retina, and a bundle of nerves (*N*), but the recent researches of Joubin prove that the function of the organ is the production and projection, not the perception, of light. It is true that no human eye has beheld the light produced by these organs which are imbedded in the skin of certain cephalopods, but they are almost identical in structure with the known luminiferous or phosphorescent organs found in some species of crustacea. When regarded from this point of view the organ may be described as follows: The nerve bundle (*N*, Fig. 2) pierces the pigment screen (*P*), which protects the adjacent tissues from the light produced in the organ, then traverses a layer of tissue (*R*), the inner surface of which is smooth and glistening and acts as a reflector, and terminates in the layer of nerve cells (*Ph*). This layer of nerve cells, which is called the photogenous layer, is the source of the light, which is projected outward by means of the concave mirror (*R*), the vitreous cone (*K*), the biconvex inner lens (*B*), and the concavo-convex outer lens.

Now the axis of this remarkable animal lantern is not perpendicular to the surface of the body, like the axes of thermoscopic and ordinary eyes, but is almost parallel to that surface. The rays emerge parallel to the bottom of a shallow depression in the skin and it has been discovered that this depression serves as a second reflector for the luminous rays which penetrate the transparent epidermis (*O*) and are bent nearly at right angles by reflection from the broad concave mirror (*Sp*), as is indicated by the arrows in the illustration. The organ has never been observed in a state of activity and I do not know that any but a conjectural explanation of this peculiar arrangement has been found. The effect of the arrangement would be to prevent the phosphorescent organs, which are distributed over the tentacles and the mantle, from showing as separate luminous points (as they would appear if their axes were normal to the surface) and to surround the predatory cuttle fish with a mild radiance which may at once attract its prey and prevent the latter from seeing it distinctly.—Umschau.

THE COLOR OF RED GRAPES.

THE coloring matter of red grapes appears to be an oxidation product of a tannin derivative present in the green grapes of either red or white vines. Thus it has been shown by M. Laborde that on heating the solid matter from either kind of green grapes for thirty minutes under pressure with two per cent of hydrochloric acid, an intense wine-red solution is obtained. A similar chromogenic property is possessed by the tannins of cherries, plums, and other fruits, but not by the tannin of oak-bark. A bright wine-red color is also obtained when the solution of one of these fruit-tannins is boiled with a little caustic alkali, and the color is permanent so long as air is excluded. If, however, the liquid be exposed to atmospheric oxidation for some hours the color slowly changes to pale yellow.

From the results of M. Malvezin's experiments, it appears that the formation of color from the chromogenic substances depends upon the simultaneous action of air and heat, and possibly of light as well. Thus when green grapes from a red vine were sealed in a tube containing water but from which all air had been removed, no red coloration was produced on heating, whereas the same kind of grapes became strongly red when placed in water and exposed for twenty-four hours to the air at a temperature of about 85 deg. C. Green grapes from a white vine were also changed to a red color when placed under the same conditions, which shows that they, too, contain the chromogenic substance. In the change that occurs naturally in the grape upon the vine, an important part is probably played by the presence of a specific enzyme (ferment), which acts as a conveyor of oxygen from the atmosphere to the chromogenic substance, and the non-occurrence of the change of color in white grapes must be attributed to their lacking this enzyme. Similar specific oxidizing enzymes, termed *oxydases*, are present in numerous plants, and are a main cause in the discolorations that take place when a cut apple or potato is exposed to the air, and of the bright blue coloration which rapidly appears when certain kinds of *boletus* are broken.—Knowledge and Scientific News.

Recent tests by naval officers of "man-lifting kites" proved, it is reported, that observations taken at a height of 2,000 feet to 3,000 feet will be of great service in discovering shoals, wrecks, submarines, and sunken mines. Balloonists have noticed that at a high altitude objects under water can be distinguished quite clearly, and these tests were to verify these claims. These "kites" have been the subject of so much experimenting in this country that they are now placed ahead of captive balloons for naval purposes, and have a not unpromising future before them. The kites possess an advantage over the balloons in their less resistance to the wind, their ability to stand practically any wind of less force than a hurricane, and in their being far less cumbersome than an inflated gas bag. Observations were taken in perfect comfort recently from a basket supported by three kites, and towed by a destroyer at a speed of 26 knots dead in the teeth of an 18-mile wind.

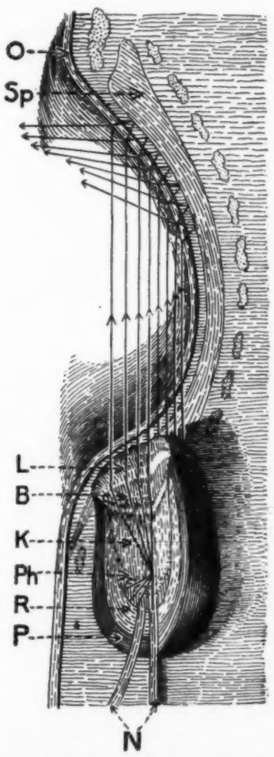


FIG. 2.—LUMINOUS ORGAN OF A CUTTLE FISH (HISTIOTEUTHIS RUPPELLI).

ENGINEERING NOTES.

According to a report by Prof. G. Weber in a German contemporary, efficiency tests of a Diesel motor of 200 horse-power, driving a direct-coupled 3-phase generator in the power plant of the foundry of the L. von Roll Ironworks, at Berne, showed the following results: Fuel used, petroleum residuum. Fuel consumption (in pounds per kilowatt-hour at switchboard), 0.62 at maximum load, 0.62 at rated load, 0.66 at three-quarter rated load, 0.77 at half rated load, 1.42 at quarter rated load. The generator efficiency varied from 91.5 per cent at full load to 77.5 per cent at quarter load, including friction and ventilation losses at 1 per cent of full load. The thermal efficiency based on effective horse-power was computed at 33.6 per cent for rated load, 32.4 for three-quarter load, 28.7 per cent for half load, and 18.7 per cent for quarter load, while the thermal efficiency based on indicated horse-power was 47.3 to 44.1 per cent, being maximum at half load.—The Mechanical Engineer.

The number of ampere turns of excitation required for an ordinary clutch, consisting of a thick disk with an annular space machined out of one face for the magnetizing coil and provided with a flat-faced disk armature of the same diameter, may be calculated from the following equation:

$$\text{Ampere-turns} = 9{,}500{,}000\ \text{LBD}\sqrt{\text{B.HP.} \div \text{A}\mu}$$
$$\sqrt{\text{BN}\ (\text{D}^2 + 8\text{RB})},$$

where L = mean length of the magnetic circuit; B = radial width of the annular pole face; D = diameter of central pole face or hub of clutch; B.HP. = brake horse-power to be transmitted; A = mean cross-sectional area of the path of the lines of force; μ = permeability of metal (say 2,500 for wrought iron); N = revolutions per minute; R = mean radius of annular pole face [= (outside diameter of clutch − B) ÷ 2]; all dimensions in inches. Thus, assuming R = 4 inches; D = 2.5 inches; B = 1 inch; L = 10 inches; A = 9 square inches; B.HP. = 4; N = 100; and μ = 2,500, ampere-turns of coil = 340. To allow for the reluctance of the joint this should be increased, say, to 400.

According to a paper read by Edward Meter before the recent Congress of Refrigerating Engineering, an interesting refrigerating plant has been installed at the Vienna Court Theater. This comprises an underground channel 26 feet in length, subdivided by a vertical partition into two halves throughout its length. The atmospheric air entering the plant is distributed along the two channels thus formed, one of which contains the refrigerating outfit, viz., 276 zinc plates superposed in six sets to which water is supplied under pressure. The air traversing this channel is cooled and saturated with moisture. The other channel contains no special outfit and serves merely for ventilating. The two air currents meet at the end of the refrigerator channel in a common ventilating pit, a set of partitions and shutters allowing the two partial currents to be mixed in a convenient ratio. The refrigerating outfit is used only on very hot and dry days. The natural temperature of the underground channel suffices under ordinary conditions. Obviously the refrigerating outfit cannot be worked during very moist weather. The cost price of the refrigerating water is about 15 cents per hour.

Strikes, revolutionary troubles, and a great dearth of coke having made the operation of the Hantke blast furnace at Czenstochowa, Poland, unprofitable, the owners decided to suspend operations until better times. In order to do away with the inconveniences and danger with which the extinction of blast furnaces is always fraught, it was decided simply to stop the blast and let the fire smoulder within the furnace. The blast was therefore stopped, all the twyers were hermetically sealed, and the furnace was charged by its mouth, first with five tons of coke, then with five tons of coke and five tons of batch, eight normal charges being made, as well as three with an excess of coke. On top of these the furnace was filled with cinders, and these covered up to the mouth with an ore containing a large quantity of clay. Finally the mouth was hermetically sealed with potter's clay. The entire surface of the furnace walls was then coated with a thick coat of pitch tar, so as to prevent air from entering through the joints of the bricks. After five months the tar coating began to scale off. As the air gained access to the inside of the furnace, the level of the contents gradually sank. After fourteen months the conditions, financial and political, of the country having improved, the owners decided to resume operations. All they had to do was to open the taphole, throw in through the mouth more coke and more batch, gradually increasing the proportion of the latter, and finally to rebuild the twyers, and start the blast anew, taking of course the necessary precautions for the evacuating of the cinders. After thirty-six hours the melt began to flow, and in a few days the production again became normal. This is probably the only instance in the history of the iron industry that a furnace has been kept banked for so long a time, and then started again without the least trouble.

SCIENCE NOTES.

Dr. Hahn of Munich has patented a process for the rapid estimation of the quantity of dust in gases. A measured volume of the gas is passed through a filter made of guncotton or other soluble absorbent. The filter is then dissolved in an appropriate liquid, in which the dust remains in suspension and produces turbidity. The degree of turbidity, and consequently the specific dust content of the gas under investigation, are then determined by optical comparison of the solution with regularly graded solutions containing known amounts of dust, or by a photometric measurement of the translucency of the solution.

After being continuously in service for approximately 150 years, the Leasowe lighthouse, which has stood on the Wirral shore of the Mersey estuary at the entrance to Liverpool, has been abandoned. This structure is the oldest lighthouse in Great Britain, and stands upon a stretch of soft sand. Its construction was somewhat interesting. Although it is a massive building, wrought in masonry, and seven stories in height, great difficulty was experienced in carrying out the foundation work. At last it was resolved to use cotton for this purpose, being considered at that time the best material for settling in the treacherous soil. Adequate supplies of this substance were immediately available, for a vessel carrying a cargo of cotton was wrecked in the vicinity, and it was dumped down onto the sand at the site, where becoming compressed it offered a stable plinth, which has never required repair or renewal. In 1765 the building was destroyed by fire, and an order was promptly issued that "no ale or other intoxicating liquors be allowed to be sold in any lighthouse," which order has remained in force ever since. For the last ten years the light was kept and tended by women.

G. Bakker has proved that the constitution of the capillary layer of a liquid in contact with its vapor depends only on the temperature, whether this layer forms the free surface of a large body of liquid or the two surfaces of a black spot in a thin film of liquid. Hence even the thinnest of black spots contains some normal homogeneous liquid imprisoned between its two capillary layers or, in other words, the thickness of the thinnest plane film is always more than twice that of the plane capillary layer of the same liquid at the given temperature. In the case of water, the thickness of the thinnest possible plane film (the black spot) is about 2 millionths of a millimeter (1/12,500,000 inch) and the thickness of the plane capillary layer is three times smaller than this. According to this theory the surface tension of a thin plane film of liquid is independent of its thickness. This conclusion has been confirmed by Johnnott's experiments. If a plane or spherical capillary layer is regarded as a continuous transition between two homogeneous phases, calculation gives, for the radius of the smallest drop that can exist in suspension in the saturated vapor of the liquid, a value of the same order of magnitude as the thickness of the capillary layer, the thermal pressure being deduced from Van der Waals's equation of states. At the boiling point, for example, the smallest drop of water in contact with steam would be about 10 millionths of a millimeter (1/2,500,000 inch).

Two French scientists, Messrs. Crouzon and Soubies, have made an interesting communication to the French Biological Society on the symptoms of balloon sickness and its most efficacious treatment. For the purpose of these investigations they made a special ascent, carrying with them reserves of pure oxygen and Agazotti's mixture for aeronauts, composed of 87 per cent of oxygen combined with 13 per cent of carbonic acid gas, in order to ascertain the remedial properties of each inhalation for treating the symptoms of the malady. One of the aeronauts experienced the first feeling of sickness at an altitude of 13,282 feet. At first a slight pain in the back of the head and nape of the neck was experienced, increasing in intensity, followed by venous congestion of the face, drowsiness, a misty vapor before the eyes when looking downward toward the earth, and finally a heavy feeling in the eyelids. As the altitude increased, drowsiness was accentuated, and the respiration became panting at 14,764 feet. In attempting to sit down, the aeronaut fell to the bottom of the car. At 14,990 feet recourse was made to the Agazotti oxygen-carbonic acid mixture, and within ten seconds relief in respiration was obtained. When 16,404 feet was gained, the feeling of fatigue was very developed, the drowsiness increased, interest in the surroundings was lost, and he did not answer questions. Whenever a slight inhalation of the oxygen or Agazotti mixture was made, however, distress was removed, but the relief was only temporary. When finally 16,700 feet was reached, continuous inhalations of the pure oxygen became expedient to secure comfort, and to remove the depressed feelings, which otherwise manifested themselves in the rarefied atmosphere. At this height only pure oxygen was found to be of any use, though the Agazotti mixture was efficacious up to about 15,000 feet.

TRADE NOTES AND FORMULÆ.

Breslau Spot Soap.—1,000 parts of white soap cut into fine shavings, then dissolved in 125 parts of water and to this 100 parts of spirits and 60 parts spirits of sal amomniac are added.

Spot-removing Soap for Calico and Silk.—640 parts of soap are shaved and melted with 300 parts of ox-gall, 60 parts of thick turpentine being added. It is made up into ball shape.

Whalebone substitute (Hunkemöller's) is made by saturating the sinews, tendons, or urethras of large cattle with a solution of a chrome salt, preferably chrome alum, to which common salt has been added, pressing it flat and cutting it into strips.

Excelsior Cleansing Fluid (Spot-removing preparation).—100 parts of deodorized benzine, 30 parts of alcohol, 3½ parts of baryta, 3½ parts of oil of wintergreen, 3½ parts of spirits of sal ammoniac, 3½ parts of chloroform, 3½ parts of sulphuric ether, and 3½ parts of powdered borax.

Span-worm Glue.—Heat 50 parts of coal tar in an iron pot with 100 parts of rosin, until the latter is melted, then add 25 parts of fish oil and finally 100 parts of common soap. With this preparation, the stems of fruit trees are treated and between the trees sheets of paper are suspended that are coated with the composition.

Spot-removing Soap.—1,000 parts ordinary white soap and 2,000 parts Venice soap are scraped fine and heated with 250 parts each of ox-gall and alum, 50 parts cream of tartar and 500 parts of potash lye; on the following day to this is added 2,500 parts of spirits of wine, 120 parts spirits of camphor and 4 fresh eggs. The mass is allowed to solidify in molds.

Blue Spirit of the English Dyers.—Carefully mix 6.1 parts of hydrochloric acid and 3.1 parts of nitric acid, allow the mixture to cool a little, upon which add the carefully prepared mixture of 1.1 part of water and 1.1 part of sulphuric acid. It is used for potash-blue dyeing, also for the ground color of cloths and tweeds (raincoat goods) dyed green and blue. To a piece take 3.3 pounds of yellow prussiate of potash and 6.7 pounds of blue spirit.

Fresson's Mass (Gold Printing Varnish).—Dissolve, in a copper kettle, in 150 parts of water, 50 parts of soda, heat to boiling and gradually add, constantly stirring, 100 parts of pulverized rosin, after which boiling is continued until the fluid appears to be no longer turbid but perfectly transparent. Then allow it to cool, pour the fluid off from the rosin soap that has settled to the bottom and dissolve the latter in 100 parts of boiling water; to the solution add 18 parts of steeped glue and 10 to 20 parts of glycerine. The exact quantity of glycerine is to be gaged according to the special purpose for which it is to be used and whether the mass is to dry quickly or slowly.

Fruit Jelly.—In the preparation of fruit jelly, unripe, or at least not overripe apples, quinces, currants, and gooseberries are best adapted. If we wish to make jelly of the juices of cherries, mulberries, or medlars, etc., they must be mixed with the juices of other fruit varieties that gelatinize well, like apples or currants. Peeling the fruit or removal of the core (as in apples) is unnecessary. The fruit is placed in shallow pans, about four inches deep, and as much water poured in as to barely wet to topmost fruits. During the boiling no water may be added. Do not boil longer than is necessary to cook the fruit, which will be at most a quarter of an hour after the first bubbling up. The scum must be carefully skimmed off. The boiling destroys the fruit tissue, and the juices, as well as the gelatinous pectic substances, pass into the hot water. To obtain the juice clear, the boiled fruit is emptied onto a closely-woven cloth and the juice allowed to run off without the application of any pressure. The residuum can be used for jam or marmalade. 500 parts by weight of sugar are added to each 1,000 parts of juice and it is then boiled down. The proper degree of evaporation is determined by the drop test. A gelatinous transparent jelly is thus obtained, of the solidity and solubility of a good meat jelly.

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